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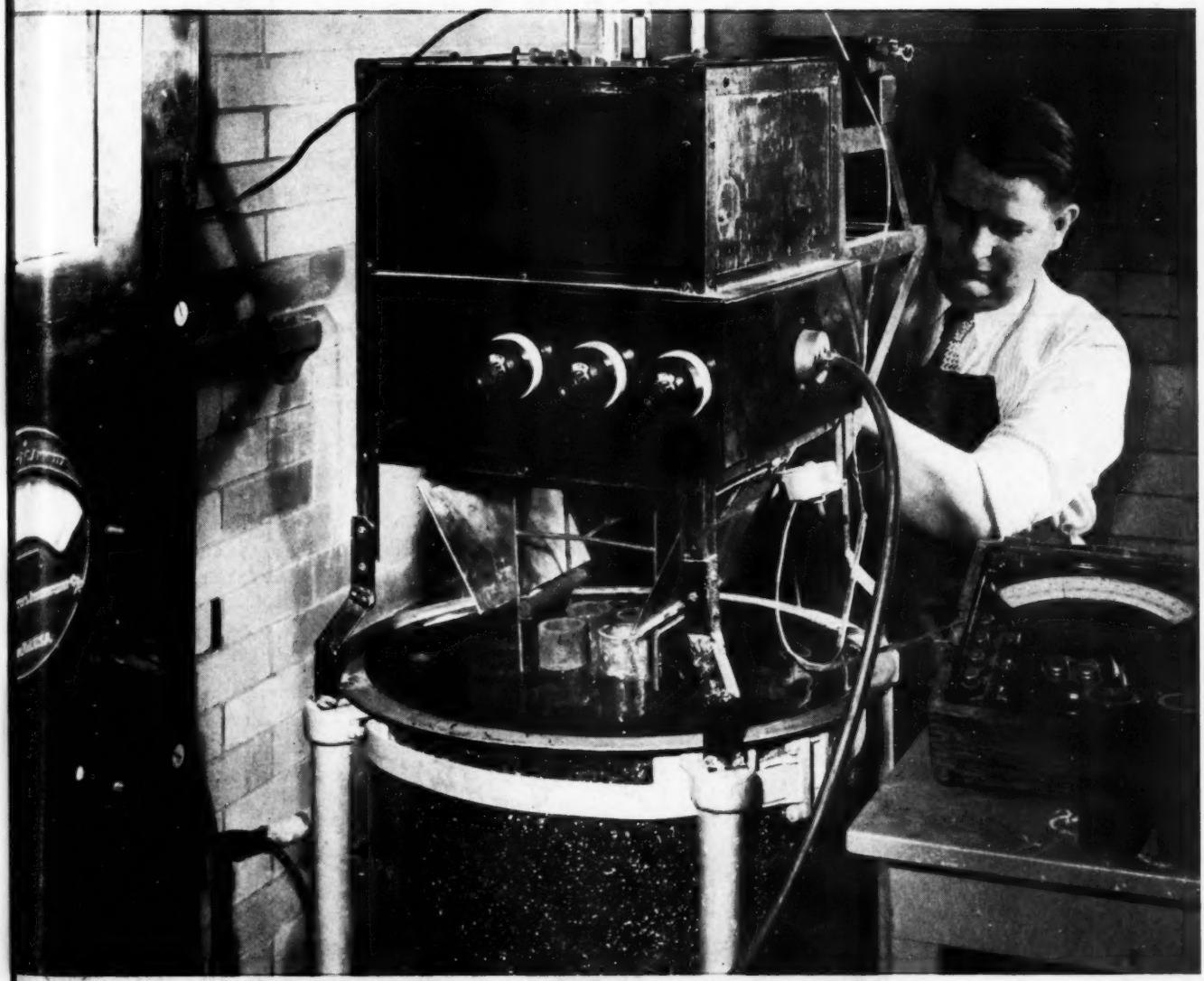

• • Glassed-steel "dunking" test. *See Page 40.*

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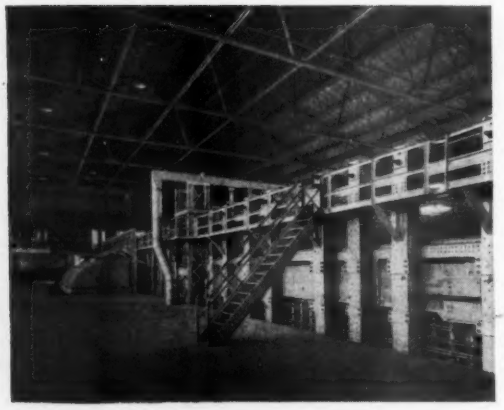

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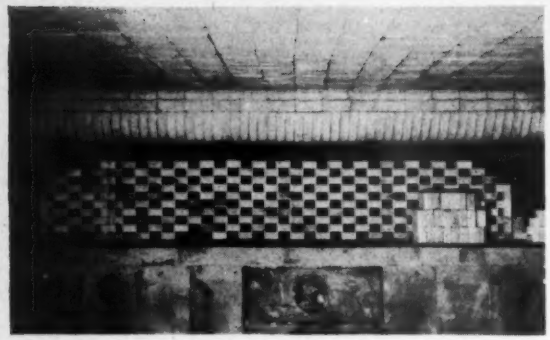

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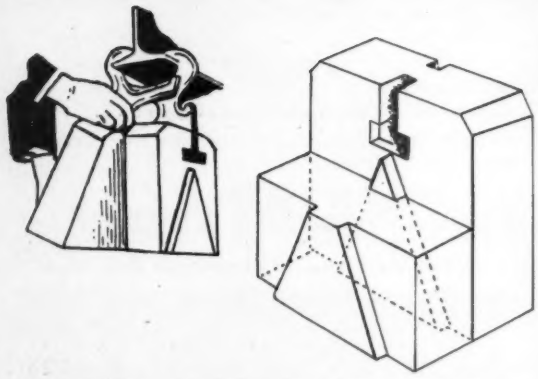

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THE GLASS INDUSTRY

VOLUME 36, NUMBER 1, JANUARY, 1955

LITHIUM DEVELOPMENT AND EXPANSION

Improved properties and new sources of supply assure availability for glass.

By H. E. Simpson

N. Y. State College of Ceramics, Alfred University, Alfred, N. Y.

I. Introduction

Owing to the growing demands for lithium products, producers have been actively searching for new sources of high grade lithium ores. The development of these new sources will ultimately make available an increased supply of these versatile and relatively new products. Four important mineral sources of lithium are lepidolite, petalite, spodumene and amblygonite.

Major producers, who formerly mined spodumene in the Black Hills of South Dakota, are opening up new deposits in North Carolina and are also active in Canada. Expansions of mining operations and plants for producing lithium chemicals are quite extensive and represent large capital investments.

Of particular interest to the glass and ceramic industries is the development of a large new deposit of high-grade lithium-bearing minerals located near Fort Victoria, Southern Rhodesia. This property is owned and operated by Bikita Minerals (Pvt.) Limited under the management of Selection Trust Limited, a London, England, mining concern with worldwide interests. Associated with Selection Trust in this enterprise is American Metal Company Limited and American Potash & Chemical Corporation, the latter serving as exclusive sales agent. The size and quality of this deposit affords a dependable continuing source of high-grade lepidolite of reasonably uniform quality. A new company, American Lithium Chemicals, Inc., has also been formed by American Potash and Bikita Minerals and will produce lithium chemicals from Bikita ore.

Lepidolite ore being loaded for shipment at Bikita.

The new interest in lithium minerals and the expansion of production facilities for lithium chemicals should be of major interest to the glass and ceramic industries which have in the past proceeded with considerable caution in the utilization of these valuable constituents because of problems of stable supply.

II. Raw Material Source

The principal lithium-bearing minerals, together with their content of lithia (Li_2O), are listed by Ladoo[1] as follows:

	Lithia content, per cent		
	Theoretical	Average	Range
Lepidolite	6.43	4	1.13-6.06
Petalite	5.71	4.49	——
Spodumene	8.1	4-7	1.2-7.6
Dilithium Sodium phosphate	22.6	20	19-21
Amblygonite	10.1	9	3.5-10

A less common lithium mineral is eucryptite ($Li_2O.Al_2O_3.2SiO_2$), which contains 13.7% Li_2O and may be useful as more of this mineral becomes commercially available. It contains less quartz and can be used as a blend with the more abundant lithium minerals.

Still other less common minerals are lithiophilite, a phosphate of manganese and lithium containing about 9 per cent lithia; triphylite, a phosphate of iron and lithium

containing about 9 per cent lithia; zinnwaldite, a micaceous mineral resembling lepidolite, but containing about 10 per cent iron oxide with 3 to 5 per cent lithia. All these minerals have been mined occasionally but are not extensive sources of supply for lithia.

According to Ladoo[1], "lithium minerals have been mined sporadically and on a small scale in various countries for probably at least 75 years, but accurate production statistics are unavailable except for recent years and then only from the United States. About 1886, France began to produce amblygonite, but lithium minerals had previously been mined in Bohemia and Saxony (principally zinnwaldite). Petalite has been mined in considerable quantities at Uto, Sweden. About 1898, spodumene was mined regularly in South Dakota, and a few years later lepidolite production began in California; then amblygonite was developed in both California and South Dakota. Later, substantial tonnages of lepidolite were found near Dixon, New Mexico. A small quantity of lithium ore has been mined or deposits reported in a few other states, namely, Massachusetts, Maine, Connecticut and Colorado. The discovery of large tonnages of spodumene in North Carolina and the development of a process for the recovery of lithium salts from the brines of Searles Lake, California, have opened huge reservoirs of lithium for industrial use and have altered all previous estimates as to reserves for future production.

"Prewar Germany was a small producer of lithium products from imported ores, largely amblygonite from Tsumeb, South-West Africa. During the war, production came from tungsten-tin mill tailings in Zinnwald, Erzgebirge, near Freiberg, Germany, which contained 0.2 to 0.5 per cent lithium in the form of zinnwaldite."[2]

"Large deposits of high-grade lepidolite occur in Karibib, South-West Africa. It is estimated that several hundred thousand tons of material are present, recoverable by open-cut mining. It contains 4 per cent lithium oxide and 2 per cent rubidium oxide. Petalite and amblygonite in considerable tonnage are also found in this area."[3]

Clark and Donahey[4] give typical analyses of the principal lithium-bearing minerals as follows:

	Lepidolite	Petalite	Spodumene	Amblygonite
SiO_2	51.74%	76.16%	62.88%	0.36%
Al_2O_3	27.48	17.24	28.61	34.42
Fe_2O_3	0.08	0.18	1.00	0.31
Li_2O	3.94	4.49	6.49	8.43
K_2O	7.40	0.39	0.89	0.30
Na_2O	0.94	0.16	0.52	1.63
MnO	0.15	——	——	——
Rb_2O	2.20	——	——	——
MgO	——	0.24	0.16	——
CaO	——	0.21	0.45	0.15
P_2O_5	——	——	——	46.75
F	7.20	0.11	——	2.61
Ign. Loss	——	0.80	——	4.30

Lepidolite. Lepidolite, lithium mica, is a complex silicate of aluminum, potassium, and lithium with fluorine and water. It contains small quantities of iron, manganese and sodium. In addition, some varieties contain rubidium and cesium. The theoretical content of lithia is 6.43, but actually the content is likely to vary from 2 to 6 per cent depending upon the deposit. The physical properties[1] are as follows:

Hardness	2 to 4
Specific gravity	2.8 to 2.9
Melting point	2 in scale of fusibility
Index of refraction	1.560 to 1.605
Color	commonly pink or lilac; also red, purple, gray, white, yellow or brown
Streak	white
Luster	pearly
Cleavage	perfect basal
Transparency	translucent to transparent

Lepidolite primarily constitutes an ideal low melting source of alumina in glass. In borosilicate type, lepidolite lowers the coefficient of thermal expansion. Increased "toughness" with decreased brittleness, tendency to reduce devitrification and harder surface have been attributed to lepidolite. Lepidolite can be used to advantage in ground as well as cover coat frits where the tolerable alumina in the formula permits 0.1 to 0.4% Li_2O equivalent.

Lepidolite can occasionally be rationalized into glaze formulae on an empirical basis. Its low melting flux combinations can occasionally be substituted for the feldspar or nepheline syenite content with a resultant brightening of surface and/or increased fluidity. A third method of adapting lepidolite is to substitute for all or part of any feldspar or syenite content a lepidolite plus flint combination balanced by calculation to have the same balanced Al_2O_3/SiO_2 molar ratio. This adaptation offers the advantage of lithia fluxing, plus the multiplicity of R_2O and RO constituents, without changing the oxide balance of the glaze. The limiting aspect of this approach is the glass forming ability of the combined silica in the original glaze versus the lesser glass forming ability of the free flint in the substitution. Where this might be evidenced in little or no reduction of fluidity or increased gloss, the flint addition can be slightly reduced with little or no effect on the oxide balance of the glaze.

A typical analysis of "Bikita" Lepidolite Ore (American Lithium Chemicals, Inc.) is as follows:

Li_2O	3.5
K_2O	7.5
F	4.0
Al_2O_3	26.5
SiO_2	55.0
Rb_2O	3.30
Fe_2O_3	0.10
SnO	0.15
MnO	0.35

Petalite. Petalite is a silicate of aluminum and lithium containing, theoretically, 5.7 per cent lithia, but the average content is somewhat lower depending upon the source of supply. Petalite is a good source of lithia in glass compositions, particularly when sodium, potassium and alkaline earths are not desirable.

Petalite, upon being heated to 2000°F. and above, converts to beta spodumene plus amorphous silica in solid solution. This crystal phase has an irreversible coefficient of expansion near zero. The linear coefficient of thermal expansion of a glass of the petalite composition is reported by F. A. Hummel[4] to be 39 x 10^{-7} when synthetically formulated, and approximately 45 x 10^{-7} when natural petalite is used.

The water solubility of petalite is lower than most

feldspathic ceramic fluxes. Ceramic bodies containing up to 75 per cent petalite plus clay have been cast satisfactorily. A mass gelling tendency is evident in the high petalite bodies which breaks upon agitation, permitting satisfactory flow even after several days' storage.

Petalite is available ground 1 per cent maximum on 325 mesh for glaze and body use. Glass and refractory grades are ground 0.2 per cent on 20 mesh with 1 per cent maximum on 30 mesh. There is also available refractory grog sized 10 x 40 mesh.

The empirical formula of petalite is not very far removed from that of a simple Bristol type glaze. Consequently, petalite, with minor additions of zinc oxide or alkaline earths, plus clay, is capable of forming simple glazes. Low expansion petalite-containing bodies, as well as zircon and alumina refractory bodies, have been satisfactorily glazed. These glazes have good gloss and are free of crazing.

Petalite is an ideal Li_2O source for frit compositions. However, additions are limited by the tolerable alumina content of the frit. Such compositions should permit at least 0.45 per cent alumina to be provided by petalite, thus making approximately 0.1 per cent lithia available.

A typical analysis of "Bikita" Petalite Ore (American Lithium Chemicals, Inc.) is as follows:

SiO_2	78.25%
Al_2O_3	17.16
Li_2O	4.79
Fe_2O_3	0.02

Spodumene. Spodumene is a lithium aluminum silicate, $Li_2O.Al_2O_3.4SiO_2$. It usually contains sodium, iron, calcium or manganese. Its theoretical composition is 8.1 per cent lithia. However, the average content is somewhat lower depending upon the source of supply. Its actual lithia (Li_2O) content may vary from 1 to 7.6 per cent.

Its physical properties[1] are as follows:

Hardness	6 to 7
Specific gravity	3.1 to 3.2
Melting point	both 1223°C. and 1417 to 1428°C. are given
Index of refraction	1.660 to 1.676
Color	white, pale green, yellow to emerald green, pink and lilac
Streak	white
Luster	vitreous to pearly
Cleavage	perfect prismatic, also easy parting parallel to orthopinacoid
Fracture	uneven to splintery
Transparency	opaque to transparent
Tenacity	brittle

It commonly occurs associated with pegmatite dikes, along with such accessory minerals as quartz, feldspar, mica, tourmaline, beryl, garnet, lepidolite, etc. One of the largest deposits being exploited in the United States is in North Carolina. Explorations have disclosed surprisingly large concentrations of this mineral at Kings Mountain, North Carolina, as well as Grover, South Carolina. Parts of the pegmatite contain 15 per cent or more spodumene. Some deposits have been traced for as much as ½ mile showing the width to be from 20 to 100 feet. The potential reserve is probably in excess of one million tons of mineral. The average content of lithia (Li_2O) is about 6.5 per cent, while the iron content varies from 0.18 to 0.5 per cent.

Appreciable deposits also occur in Pennington County, South Dakota. These deposits are distinguished by large crystals up to 6 feet thick and 42 feet long, are found in abundance in a very coarsely crystallized pegmatite and are associated with typical other pegmatite minerals. Smaller deposits occur near Pala, San Diego County, California, as well as areas near Huntington, Chester, Chesterfield, Goshen, Leominster and Sterling, Massachusetts.

Spodumene has been used to a minor extent in numerous glasses over a great number of years (since its inclusion with lepidolite mined in New Mexico, 1920). Little has been recorded in the journals of its specific use and behavior. Spodumene, nonetheless, has established itself as an effective glass batch source of lithia and alumina.

Spodumene is currently available in limited quantities. However, there are large reserves and high-grade ore is expected to be available in substantial tonnages within a few years.

Spodumene converts, upon being heated to 1800°F. and above, to beta or high spodumene with a marked volume increase. Under these conditions, the specific gravity changes from 3.2 to 2.4. This conversion is irreversible.

The solubility of spodumene is slightly less than the average commercial feldspar. No casting problems are encountered. However, slightly more electrolyte is generally necessary to produce a successful casting.

Spodumene in one of its various low melting combinations has proven ideal to soften and brighten glazes. Spodumene is used in ground coat frits in which up to 0.4 per cent Li_2O will materially lower the firing range.

Amblygonite. Amblygonite is a phosphate of lithium and aluminum with fluorine and usually contains some combined water. It frequently occurs as coarse, white, cleavable aggregates or rounded masses, sometimes in large indistinct crystals. It is one of the least expensive sources of alumina-phosphate, forms some of the lowest melting eutectics and contains the highest lithia of any of the lithium minerals. Amblygonite is available ground 95 per cent passing 325 mesh.

Its physical properties[1] follow:

Hardness	6
Specific gravity	2.88 to 3.09
Melting point	2 in scale of fusibility
Index of refraction	1.579 to 1.597
Color	usually white, sometimes with brown, yellow, green or blue tints
Streak	White
Luster	vitreous to pearly
Cleavage	perfect in one direction, imperfect in two or three others
Fracture	uneven
Transparency	translucent to opaque
Tenacity	brittle

Its use in glasses is primarily devoted to applications in opal and alabaster glasses. In enamels it has had application in zircon-type sheet steel cover coats and as a base for certain phosphate-base compositions. It has been used as a mill addition up to 2 per cent in hollow-ware ground coats and/or cover coats. In such use the firing temperature can be reduced up to 80°F. Additions in excess of 2 per cent have been noted to increase the viscosity of such enamels.

Aerial view of American Potash & Chemical Corp. plant at Trona, California.

Trona Licons. Lithium is also produced as a by-product from Searles Lake, California,[1] as $Li_2Na(PO)_4$. According to Gale[5] this was considered a by-product until 1942, when wartime demands elevated it to the rank of co-product. The brine, with a content of 35 per cent dissolved solids, contains LiCl to the amount of 0.033 per cent. The dilithium sodium phosphate accumulates with burkeite, a double salt of sodium carbonate and sodium sulfate, which is a residual product from the evaporation processes. This material is prepared properly for flotation until it has about 0.2 per cent solids in suspension. This liquid is conducted to flotation cells, and the lithium product floated and collected as a concentrate. The concentrate, containing from 19 to 21 per cent Li_2O, is then chemically converted to refined lithium carbonate and packaged for shipment.

III. Industrial Lithium Chemicals

Lithium Hydroxide Monohydrate, $LiOH.H_2O$. Lithium hydroxide monohydrate, $LiOH.H_2O$, will be available in considerable quantities within the coming year and will, no doubt, serve as a very useful raw material for glass, enamels, glazes and the like.

Lithium Carbonate, Li_2CO_3. Lithium carbonate, Li_2CO_3, is available in high purity and is quite reactive. It is relatively concentrated and one of the most economical of the manufactured sources of Li_2O. It is most useful in glasses where high purity is important and in conditions where the impurities of lithium minerals cannot be tolerated. It is most reactive as a vitreous enamel frit addition and is occasionally used in the mill addition of enamels and glazes, as permitted by the effect of its relatively low solubility on glaze viscosity or enamel set.

Lithium Fluoride, LiF. Lithium fluoride, LiF, is virtually insoluble and is useful in glasses, glazes and enamels where the fluorine content is desired. It is the most concentrated manufactured source of Li_2O equivalent. It also has value in the manufacture of opal and alabaster glasses.

Lithium Metaborate, $LiBO_2.2H_2O$. Lithium metaborate, $LiBO_2.2H_2O$, is used principally in glasses where very low melting compositions are desired and where the B_2O_3 is of value.

Lithium Silicate, Li_2SiO_3. Lithium silicate, Li_2SiO_3, has found limited application and advantage in glasses where less alkali volatilization is desired.

Many other lithium compounds, such as the nitrate, $LiNO_3.3H_2O$, lithium cobaltite, lithium manganate, lithium citrate, lithium chloride, lithium phosphate, lithium titanate, lithium zirconate and other lithium compounds of heavy metal oxides, all have specific applications. It appears, however, that the most important lithium industrial chemicals, as far as the glass and ceramic industries are concerned, are lithium hydroxide and lithium carbonate.

IV. Fundamental Advantages of Lithia*

In considering the various fundamental characteristics of metallic lithium, as well as its oxide lithia (Li_2O), the investigator should remember that lithium is the lightest of all metals. It has an atomic weight of only 6.94. The oxide, molecular weight 29.88, is extremely light in comparison to Na_2O (62.0) or K_2O (94.2).

Such differences in oxide molecular weights indicate the futility of comparing the properties of the alkalies, especially when the comparison is made on a weight rather than a mol basis. The following table illustrates the differences between weight and mol per cent ratios of various alkali silicates.

TABLE I

Mol Formula	Mol Per cent Alkali	Weight Per cent Li_2O	Na_2O	K_2O
$R_2O.5SiO_2$	16.67%	9.1%	17.1%	23.8%
$R_2O.4SiO_2$	20.0	11.1	20.5	28.1
$R_2O.3SiO_2$	25.0	14.2	25.6	34.3
$R_2O.2SiO_2$	33.33	19.9	34.1	43.9
$R_2O.SiO_2$	50.0	33.2	50.8	61.0
$2R_2O.SiO_2$	66.67	49.9	67.4	76.0

The majority of the ceramic oxides produce ions which are considered, for the most part, as spheres and in which the ionic radius has a real meaning. Zachariasen[6] has given a comparison of these ionic radii as shown in the following table.

TABLE II
Ionic Radii of Zachariasen[6]
(In Angstrom Units)

Li^+	0.68	Be^{+2}	0.39	B^{+3}	0.24	O^{-2}	1.40
Na^+	0.98	Mg^{+2}	0.71	Al^{+3}	0.55	F^{-1}	1.33
K^+	1.33	Ca^{+2}	0.98	Si^{+4}	0.44		
Rb^+	1.48	Sr^{+2}	1.15	P^{+5}	0.34		
Cs^+	1.67	Ba^{+2}	1.31				

As might be expected, the lithium ion has the smallest ionic radius of the alkalies and is approximately the same size as the Mg^{+2} ion. It is not surprising, therefore, that LiF should be isomorphous with MgO, with the bond in the former compound being weaker than in the latter.[7] The substitution of Li^+ for Mg^{+2} may be made structurally, provided an adjustment of valence follows. The substitution of Li^+ plus Al^{+3} for $2Mg^{+2}$ appears to be a possible explanation for the lithium spinel structure.[8]

*In assembling fundamental data on lithium, the author is permitted to use data from an excellent paper by J. D. Clark and J. W. Donahey, "Lithium in Glass, Glazes and Enamels," *Foote Prints* 22 (No. 2) 9-21 (1950).

Actually, the size of the ion is so similar to that of Mg^{+2} that its chemical and ceramic properties frequently parallel that expected of an alkaline earth. It is this property, primarily, which sets lithium apart from the other alkalies.

Lithia is believed to form so-called "contracted" or "condensed" glasses, glasses having higher densities than might be expected from calculation.[9] Certain lithium minerals, such as eucryptite and spodumene, upon fusion form glasses having higher densities than the equivalent crystalline form.

A practical application of this tightening effect is found in the ability of lithia to effect considerable improvement in the surface hardness of glasses and glazes. This property was recognized by early users of lepidolite as a glass constituent. Koch, Harmon and O'Bannon[10] showed that the replacement of PbO, Na_2O and K_2O by Li_2O or BeO increased surface hardness of a whiteware glaze as much as 20%.

Heidtkamp and Endell[11] measured the viscosity of bisilicate melts through the range 10—10^4 poises and demonstrated that from 1000—1400°C., $Li_2O.2SiO_2$ had the lowest viscosity, with $Na_2O.2SiO_2$ and $K_2O.2SiO_2$ having higher viscosities in that order. It should be pointed out, however, that the composition $Li_2O.2SiO_2$ corresponds very nearly to a eutectic in the Li_2O—SiO_2 system and that the choice of this ratio may have been unfortunate.

Actually, it appears probable that in the very high viscosity ranges (i.e., at low temperatures), the viscosity of simple lithia glasses may be higher than those of the corresponding soda or potash glass, since the first bonds to be broken with heat addition are probably the alkali-to-oxygen bonds. The dialatometer "softening temperature" results are indicative of this range. As temperature is increased, however, the viscosity of lithia glasses drops off more rapidly than the soda and potash glasses. At lower viscosities (viscosities which are in the actual range of interest to the ceramist), the lithia glasses are the most fluid, reversing the previous condition. These lower viscosities are explained by the action of the lithium ion in weakening the bonds in the glass network proper.

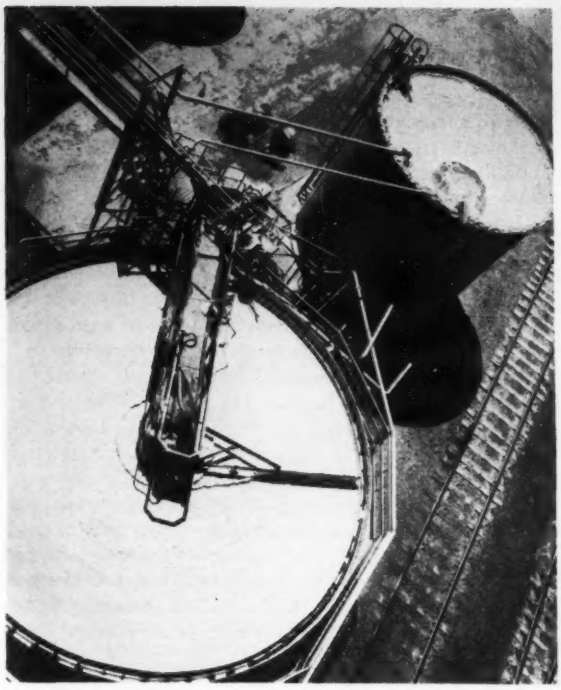
It has been recognized by some investigators that the fluxing power of lithia is not as pronounced in the more highly siliceous glasses (for example, porcelain glazes) as in low temperature compositions (enamels). Nevertheless, it is generally found that small additions of lithia will lower the fusion temperatures of even high temperature glasses. The author has found lithia to be an excellent flux in glasses containing as high as 80% silica (SiO_2).

The strong field strength of the lithium ion, which leads to contraction of glasses, also manifests itself in other characteristics. The pronounced tendency of simple lithium silicate glasses to devitrify, noted by Schott[12] as early as 1880, is related to this strength.

The tendency is so great in respect to the lithium-silica glasses that few of the properties of these glasses have been studied. Practical glasses of high lithia content are almost unknown.

On the other hand, lithia extends the ranges of glass formation of some glasses similar to the phosphate glasses.[13] The metaphosphate, $LiPO_3$, for example, may be fused to a clear glass without devitrification, while KPO_3 may not.

In common glass, glaze or enamel composition, the presence of considerable quantities of lithia will not cause devitrification and may even extend the field of glass formation. These compositions, of course, are generally complex and, therefore, inherently stable. In addition, they will frequently contain stability promoting oxides, such as those of lead or aluminum. Nevertheless, combinations of lithia with other alkali ions have been shown to extend glass formation fields to a considerable degree, even in the absence of stabilizing ions. This property can be employed to advantage in "soft" glasses and in low temperature enamels and glazes.



Lithium flotation tank at Trona.

This contradictory behavior of lithia is understandable in the light of a recent article by Forland and Weyl.[14] Discussing the conditions favorable to glass formation, the authors state that the presence of network-modifying ions of widely different field strengths contributes to glass stability.

The influence of lithia on the thermal expansion of glass has been a subject of great controversy. The thermal expansion factors of Winkelmann and Schott, published in 1894, have been severely criticized because of the value which they assigned to lithia, a value which indicated that lithia, pound-for-pound, contributed far less to high expansion than either soda or potash. In 1934, Waterton and Turner[15] published the following factors:

Li_2O	4.9×10^{-7}
Na_2O	4.18×10^{-7}
K_2O	3.4×10^{-7}

In the absence of evidence to the contrary, it may be assumed that this effect is typical of all glasses; i.e., the molar substitution of Li_2O for other alkali will always lower thermal expansion. The ceramist takes advantage of this property in the formulation of low expansion glasses. Moreover, because of the fluxing properties of lithia, it is frequently possible to reduce the total amount of alkali, thus accomplishing a further decrease in expan-

sion. Applications of this principle are frequently found in porcelain enamels, glazes and glass.

Dietzel[16], Badger and others have studied the effect of lithia on surface tension. In all cases, lithia is found to increase surface tension, whether substituted on a weight or molar basis for other alkali.

Williams and Simpson[17] used the maximum-bubble-pressure method to determine the effect of lithia on the surface tension of various silicate melts. They found the change in surface tension to be non-linear, depending upon the composition of the base melt and the temperature, as well as the concentration of lithia. In glasses and enamels, lithia increased the surface tension; with glazes, however, the surface tension was reduced sharply.

In view of these fundamental data, it would appear that the small size of the lithium ion greatly influences its function in glass, glazes and enamels. The lithium ion possesses an unusually high electrostatic field, which is further magnified by directional effects. This characteristic accounts for its strong fluxing effects, lowered viscosity and extension or broadening of the field of glass formation. In general, when lithia is substituted in part or wholly for other alkalies, thermal expansion is lowered, refractive index is raised and chemical resistivity is improved. Finally, in comparison with other alkalies, lithia raises surface tension.

V. Application of Lithia in Glass

Of the lithium ores available, it appears that lepidolite and petalite show the most promise for use in the glass industry of the future. Spodumene is very important, but owing to its initial high iron content, it is more likely to be used as a source of lithium in the production of other industrial lithium chemicals rather than as a direct source in glass. Where high iron is permissible, however, it may be used as a source of lithium.

Amblygonite offers possibilities where available and may be useful where it is desired to take advantage of the phosphate content. Eucryptite, on the other hand, will serve principally as an accessory ore that is useful in blending with other ores that are quite high in silica. The advantages in using lithium in the glass batch will no doubt be developed in the future along the lines of reducing melting time and improvements in the meltability of a particular batch.

Lithia probably finds its greatest use in applications which take advantage of its ability to lower the fusion temperatures of ceramic mixtures. Low temperature glazes, glasses and enamels generally incorporate some portion of lithia because of this effect, while lead-free compositions of all types almost invariably are based on the use of lithia.

Armistead[18] has shown the advantages of lithia for glasses used for a variety of purposes such as the manufacture of tubes and bulbs and subsequent fabrication into electric-sign lights, cathode ray tubes and the like. The following glass compositions, together with certain physical properties, are given in the above-mentioned patent.

	1	2	3	4	5	6	7	8	9	10
SiO_2	71.7	71.7	69.7	68.5	70.1	66.5	63.3	59.3	58	70.4
Al_2O_3	8.4	8.4	10.4	8.4	8.4	7.5	6.7	6.7	7	7.5
K_2O	2.6	6.6	4.6	4.6	2.1	2.5	6.6	8.6	8	2.5
Na_2O	14	10	12	11.2	13.7	11.5	5.7	1.7	3.5	14.5
Li_2O	1.3	1.3	1.3	1.3	1.0	1	1.0	1.0	1	1.1
F	2	2	2	2	1.7	2	1.7	1.7	1.5	2
ZnO	....	....	....	4	....	....	....	....	....	....
BaO	....	....	....	.....	3	9	15	21	18	....
CaO	....	....	....	....	....	....	....	....	3	....
B_2O_3	....	....	....	....	....	....	....	....	....	2
Softening Point, °C.	623	646	638	637	632	628	652	690	692	631
Strain Point, °C.	386	395	401	409	395	401	415	452	460	404
Soft.-Str.	237	251	237	228	237	227	237	238	232	227
Exp. X 10^7	92.8	91.0	91.6	90.2	91.1	91.3	90.3	87.0	89.2	89.6
Sp. Gr	2.41	....	....	....	....	2.56	2.65	....	2.75	2.41
Ohm cm. X 10^{-5} @350°C.	1.5	11	4	6	2	6.6	170	1,930	1,480	2
Stability	.07	....	....	....	....	.15	.18	....	17	....
Batch Cost in cents per lb. of glass	1.7	....	....	....	....	2.0	2.6	....	2.7	1.7

The advantages obtained are more economical batch, lower density and desirable electrical properties. Still another patent of Armistead[19] makes use of lithia in glasses having suitable characteristics as an insulating medium for conductors carrying radio frequency currents. These glasses contain approximately 0.5 to 2.0% Li_2O.

Lithia offers interesting possibilities in its effect on borate glasses. Grenet,[20, 21] who first published work on alkali borate glasses in 1896, showed that minimum expansion in the Na_2O-B_2O_3 system occurred at approximately $Na_2O.5B_2O_3$, whereas the equivalent inflection in Li_2O-B_2O_3 system occurs at about $Li_2O.4B_2O_3$. The linear coefficients of expansion are given as 8.5 x 10^{-6} and 6.2 x 10^{-6}, respectively. Low expansion glasses of the lithium-borosilicate type would therefore appear to offer considerable possibilities.

Lithia offers the greatest durability of any of the alkali constituents of glass. The resistance to attack by moisture is probably greatest when lithia is used because a large number of its alkali salts are frequently insoluble, or at

(*Continued on page* 46)

FIFTEENTH CONFERENCE ON GLASS PROBLEMS

Over 350 men interested in glass technology gathered on December 2 and 3 in the Archeological and Historical Museum on the Ohio State University Campus, Columbus, Ohio, to participate in the Fifteenth Annual Conference on Glass Problems. This was the largest attendance on record for this Conference and Drs. Blau and Tooley provided an excellent program. After registration, the group was warmly welcomed by Gordon B. Carson, Dean of the College of Engineering, Ohio State University, who urged everyone to relax and become better acquainted and take full advantage of this opportunity for a full exchange of ideas. He warned that "we argue not at the Conference, but argue with our problems at the plant."

Dean Carson reminded his audience that in spite of the efforts of science, man cannot do with a blade of grass that which a cow can do. Saliva is still the best wetting agent known to mankind, and in spite of all the work of glass technologists, we still do not know why light goes through glass. Dean Carson also pointed out the desirability of mutual exchange of ideas with other fields of science and other branches of engineering. Analogous art is always a fine study. It is by means of such conferences that today's masterpieces are created and ultimately result into tomorrow's museum pieces.

The morning session, Thursday, December 2, was devoted to problems related to seeds and fining in glass manufacture, and H. W. Baque, Corhart Refractories Company, was Chairman.

Bubbles in Glass—The Problem and Some Approaches to Its Solution. *By R. K. Day, Libbey-Owens-Ford Glass Co., Toledo, Ohio.*

Dr. Day gave a most interesting paper on the general problem of bubble formation in glass with its various related difficulties of seed formation, blisters, etc. He defined his terms by stating that "a bubble is a globule of air or gas within a liquid." This definition seems to satisfy the phenomena found in glass. A bubble is round or tries to be as round as it can because surface tension forces try to make it round. Positive surface tension tends to shrink a surface to the smallest area it can possibly achieve, and this tendency causes any volume of gas or air which has been trapped in the molten glass to attempt to become a spherical bubble. It was pointed out that when soft glass is rapidly stretched during cooling, as for instance in the case of commercial window glass, the spherical bubbles may become elongated simply because they have not had time to become spherical again before their shape is frozen in the cooled glass.

The application of the theory of Stokes' Law, which relates rate of rise of bubbles directly to their squared diameter and directly to the glass density and inversely to its viscosity, was pointed out. This law is believed to be valid when the containing walls are relatively distant. As an example, a temperature drop from 2450°F. to 2000°F. in a soda-lime glass causes a ten-fold increase in viscosity, thus slowing down the rise of bubbles by a factor of ten. Similarly, a temperature rise of about 125°F. in the same temperature region will double the rate of rise. An increase in bubble diameter from .003 inches to only .010 inches (square law) speeds up the rise by a factor of eleven. Unusual glass compositions will have their own characteristic viscosity curves which may be different from those described above.

Probably the most important thing about bubbles in glass is their conception, or "how are they created?" The pressure P inside of a bubble is equal to $\frac{4T}{r}$ where P is the pressure in the bubble, r is its radius, and T is the surface tension.

$$P=\frac{4T}{r}$$

when r is zero, the pressure infinite, and contained theoretically in a homogeneous medium, it would be impossible to start the bubble. It was pointed out that when water is boiling in a glass beaker, the severe bumping can be avoided by placing a piece of inhomogeneous material, such as porous porcelain, in the beaker. The bumping is relieved owing to a rapid sequence or rapid rise of bubbles from the inhomogeneous surface of porous porcelain. This experiment is a good demonstration of how bubbles tend to form at rough surfaces or interfaces and do not tend to start even at the smooth interface of the water with the glass beaker. The water is supersaturated with steam at this temperature just above its boiling point, and each new steam bubble which may form to help relieve the saturation has to find a speck or other inhomogeneity on which to get started. The availability of nuclei to allow bubbles to start may therefore be a measure of the opportunity for bubbles to be formed.

Laboratory experiments were cited in which a certain commercial glass was melted at 1400°C. in two and a half hours free from seeds. The same glass melted under similar conditions but with a small piece of refractory material added produced very seedy glass which persisted after 48 hours heating. In commercial melting in high speed tanks, such tanks are not melting their capacity in a 24-hour day. The major portion of the glass in the tank lingers and circulates and may travel to a previously stagnant corner and bring trouble back into the stream in the form of inhomogeneous material or inhomogeneous glass.

Molten glass is known to be supersaturated with such gases as CO_2, SO_2, H_2O vapor, etc., and upon striking inhomogeneous surfaces as described above, they are logically aided in ridding themselves of this supersaturation in the formation of bubbles and seeds. The basic cause of seeds is believed by Day to be that bubbles are formed only at points

of inhomogeneity in a melt. Other factors, such as "reboil," atmosphere over the melt, sudden changes in temperature and high temperature melting, were discussed.

The limitations of statistical analysis of production and quality data were discussed. It was strongly recommended that industry make use of running bubble count charts. Effort to correlate changes in bubble count with changes in furnace operation can point the way toward operating furnaces with less bubble trouble. This excellent paper was enthusiastically received. It is recommended that more papers of this type be presented.

Some Practical Aspects of Seeds and Fining. *By J. W. Wright, Owens-Illinois Glass Co., Alton, Illinois.*

Mr. Wright presented a most practical paper and did not attempt to offer any theory or scientific explanation of seeds. His remarks were based on a wide and extensive experience in practical plant operation largely gathered in the manufacture of glass containers.

Most seed trouble and fining difficulties can be traced to partially decomposed sulfates or sulfides. These difficulties are, as a rule, traced to sulfates in the batch although some instances were noted where S from fuel oil and fuel gas was a contributing cause. Batch segregation usually accompanied such troubles. In general, higher furnace temperatures tend to eliminate seeds, providing the refractories can withstand the increase in temperature without severe corrosion or chemical attack.

Amber glasses are likely to show seeds. One example was noted where such a glass was cooled below its normal working temperature, and upon reheating the seeds disappeared. It was reasoned that the seeds were frozen-in on cooling and on reheating were dispelled. Amber glasses have shown a greater tendency to form seeds than green or colorless glass.

Many practical aspects were considered, such as the method of production feeding. Suction feeding in the Owens machine requires that better quality glass be presented to the feeder. A similar problem exists with gravity feed, and the revolving tube or stirrer coupled with contamination by refractories along the narrow charging trough may aggravate seedy conditions.

Rapid pull on the tank will influence seed formation providing the rate of pull is sufficiently strong to interfere with proper melting and cause inhomogeneity in the glass. Sodium sulfate is highly influential, and the sulfate impurities in batch ingredients as well are contributing causes. Borates and barium sulfate have caused an aggravated seedy condition. Opal glasses appear to retain gases without seed formation better than clear or colored glasses. In this case the gas is believed to be fluorine.

In conclusion Mr. Wright stressed the hazard of sulfates as the cause of seeds and pointed out that this source of contamination might be varied and extensive.

Seeds and Fining in Optical Glass Manufacture. *By C. F. Cala, Bausch & Lomb Optical Co., Rochester, New York.*

The procedure of melting in the optical glass field was first described. Borosilicates, crowns, dense barium crowns and dense flints are the general types used and comprise about 150 different compositions, all made to careful specifications covering index, transmissions, density and quality. It is hoped in the future to reduce this number to five or six types.

Seeds are one of the most important and serious defects. In most optical glasses, one seed per cubic centimeter is permissable and in barium crown glasses two seeds per cc. are permitted. Bubbles up to 0.5 mm. in diameter are considered as seeds.

The fining process is the one in which glass approaches elimination of dissolved gases. As a rule, the optical crown glasses contain more seeds than borosilicate glasses. Dense barium crowns produce the greatest seeds and result in difficulty in melting.

A desirable technique is to melt as rapidly as possible at high temperatures at first and then drop to lower temperatures for holding at a long time. Seeds at refractory interface are always more prominent, indicating solution of refractories.

Lead glasses tend to have fewer seeds and tend to react less with the crucible. A comparison of the various type optical glasses are as follows:

	Size	JANG	Av. No. of Seeds Standard (10cc.)
BSC	.25 mm.	10	.28
C	.20 mm.	10	4.50
DBC	.25 mm.	20	12.00
BF	.05 mm.	10+	12.00
DF	.10 mm.	10	.20

Refining techniques used are "blocking" by means of potatoes and wood. Arsenates, antimony, cerium (should not be used with arsenic or antimony), barium sulfate, sodium sulfate, sodium fluoride, fluorine, barium peroxide, etc., are also used. Salt (NaCl) is not desirable owing to the corrosive effects on molds.

The continuous method of manufacture of optical glass has been in use since 1948 in an all fused-cast furnace. This method, employing a dual melting technique in which natural gas is used as a fuel and electrical boosting employed for fining, effectively reduced seeds and striae difficulties. Once melted, glass refined in platinum without recontamination is also an important aspect of the process. Bubbling air or other gases into the glass has been used to bring out dissolved gases and has proven beneficial. The use of fused-cast refractories has been a great aid to the process. This type of melting is said to reduce the count in a volume of glass from a million seeds resulting from pot making to eight seeds by continuous melting. Potassium iodide has been employed with success and is said to reduce the number of seeds by 50 per cent. Improvements in domestic production of optical glass are now such that foreign imports have become inferior in quality. Spectacle glass of optical quality is now being produced.

There was considerable discussion raised. It was pointed out that water can be increased in viscosity by 60,000 fold by the presence of bubbles. This effect no doubt influences fining operations in glass. Some glasses do not plane-out at all. The effect of iron oxides and its variable stability at different temperatures may influence the fining operation. The use of cast pots was said to give better quality glass than hand-made pots. The use of sodium chloride with high iron glass was said to be useful and successful as a fining agent.

Under the capable leadership of T. B. Kendrick, Lancaster Lens Company, the afternoon session provided lively discussion and many comments.

Evaluation of Metal Defects in Plate Glass Manufacturing. *By H. J. Knighton, Ford Motor Co., Dearborn, Michigan.*

In the automobile industry, an important proportion of the assembled product is glass. Inspection is quite critical, and specifications are rigid. Ninety thousand tons of plate glass per year are used in automobile manufacture.

The reasons for poor quality and their frequencies were listed as follows: (1) Cords or ream, 40%; (2) Bubbles and seeds, 30%; and (3) Stones, 30%.

Ream, which is considered as a non-homogeneous layer in flat glass, offered the most serious difficulties and greatest troubles. This defect showed up at the end of the annealing lehr, and tests were made at this point. Single and multiple ream was evident at times. In the event of aggravated ream troubles, the entire production was devoted to cullet because

only labor and fuel costs were lost. The difficulties of ream would often show up as follows: (1) ream came into one end of ribbon and continued. Believed due to devitrification. (2) Ream appeared periodically. Usually due to variation in temperature of spout and refractory contamination. Flux blocks and transfer blocks renewed. (3) Ream appeared quite suddenly across ribbon. Batch house contamination often the cause. (4) General ream appeared with no definite location in ribbon. Usually associated with cords.

The following corrections were made: temperature increased and decreased in furnace; batch house and weighing checked. Lumpy salt cake was often found to be the cause of trouble, as well as variation in speed of rolling machine and presence of salt water. One bad epidemic of ream of a general character (4 above) was shown to originate at the spout entrance block. The remedy was the renewal of spout entrance block.

Bubbles and seeds are believed to be due to the following causes: (a) Conspicuous drop in temperature at melting bed. (b) Radical change in cullet ratio. (c) Installation of new rolling machine. (d) Foreign materials in glass tank. (e) Reaction of glass and refractories. (f) Variation in salt water areas. (g) Variation in salt cake to sand ratio. (h) Variation in production rate and pull on furnace.

The problem of stones was discussed in a general way. Electrocast refractories on side walls have provided a vast improvement and considerable reduction in contamination by stones. Other factors causing stones were: major changes in furnaces, repairs or overhauling of equipment, maintenance of crowns or superstructures and improper location of salt-water pools in the tank.

It was suggested that this Glass Conference should propose a performance standard on which good plate glass production could be judged. The problem is basically to produce glass of quality inherent in the process.

Forced Air Circulation in Electrical Lehrs. *By G. Adeline, Cobelcomex, Brussels, Belgium.*

Mr. Adeline attempted to show the merits and advantages of electrical annealing. Belgium engineers were said to be one of the first to apply forced air circulation in the annealing of glass.

The annealing problem was outlined as follows: (1) Bring glass to a temperature sufficient to relieve strains. (2) Maintain temperature for adequate time. (3) Maintain temperature gradient for proper cooling and at the same time avoiding reoccurrence of strain.

The thickness of the glass and its shape influence absorption of heat; color also plays a part. Convection currents within the lehr are desirable, and forced convection is usually maintained. Ventilation is also important to control. Uniformity of temperature must also be made. Convection currents are the best basis of controlling the uniformity of temperature.

Some advantages of electrical annealing were given as follows: electrical heating does not depend upon disposal of combustion products; convection is better controlled by electric heating; electric current can be turned off and on as desired, and control thus becomes more accurate and specific; there is no loss in heat by loss in combustion products; the life of the lehrs is considerably longer than lehrs using other fuels, no refractories are needed because the lehrs may be made entirely of metals; the conveyor belt remains flat and is not subject to pronounced heat shock; the maintenance of lehr is quite low, for replacement of elements requires only a few minutes instead of a major shut-down; no foundation is needed and the lehrs may be easily moved. In addition, the heating is very fast, and floor space required is small.

Examples of a number of installations in Europe were shown. The following features and characteristics were stressed: a number of short units compose the larger lehr, thus resulting in greater control; ventilation has been provided by lateral air circulation although some systems utilize vertical air circulation for higher lehrs; through alteration of the direction of ventilation in each unit, a greater degree of control and uniformity of temperature were maintained.

A complex tortuous circuit of air circulation was shown with some lehrs that permitted controlled annealing of a wide variety of wares; that is, concerning shape, size and thicknesses. Flexibility of operation was stressed by the use of variable size fans which are quickly installed. The use of baffles was also shown, as well as the variety of closed and opened doors, to provide economy and flexibility in operation.

Data on operation the past eight years have shown that the lehrs varied from 1-5 ft. in width, 10-50 ft. in length, and the time of annealing from 20 minutes to 2 hours.

Decorating lehrs have also been proposed, as well as lehrs for the annealing of plate and optical glass.

Fire Hazard and Prevention in the Glass Industry. *By R. Zink, Factory Insurance Association, Chicago, Illinois.*

The hazards of fire in the container industry seem to be greater than in other branches of the glass industry. However, generally the packing of the ware offers some difficulties. More hot oils, oily machinery and open construction as hazards are also present. In fact, glass packing materials used, such as straw, offer fire hazards. The fuel used and fuel storage piping are other possible sources. Warehouse protection is vitally needed because the mere presence of combustibles is a hazard.

Fuel storage, oil used on molds, and hot molds cause volatilization and vapors. Accumulation of oil on floors and ceilings produces many hazards around the machines. A glass gob missing the mold may ignite material on the floor. Intense heat around the machines may ignite circulating oil. Wind ducts tend to aggravate the situation and whip up fire and add to draft. Oil deposition on floors, roofs, rafters and joists ignites easily.

Stand-by equipment, such as fire extinguishers, are desirable and their use is highly recommended. In order to reduce these hazards, non-combustible mold lubricants are being considered. House cleaning of floors, roofs, rafters, etc., at frequent intervals is desirable to form a fire break and reduce the hazards. The use of materials to absorb oil accumulation is further recommended.

Automatic sprinklers have been used with some success. Manually controlled nozzles to provide a fine spray have been proposed. Where used, this system has reduced the damage to a minimum. The nozzles are installed several feet below the roof, and direct the spray toward the roof. With additional field experience, it is hoped to make these automatic in operation. Some automatic installations have been used with varied success.

Fire walls to separate the storage areas from the manufacturing areas are needed to prevent the spread of fires. Private fire brigades are desirable. Secondary water supplies and pools are often needed and often necessary in large plants. Private guard hydrants aid under emergency conditions. Cutting and welding operations are often a cause of fire. Issuing of permits is desirable for such operations and places the responsibility of hazardous work on the shoulders of one person so that the hazards may be reduced and careful control provided.

The use of fire-retardant coatings in vital areas is a partial preventative and has been applied with some success. The concluding opinion was to exercise constant surveillance and practice good housekeeping.

Silicones in the Glass Industry—A Progress Report. *By T. Mahoney, Linde Air Products Co., Tonawanda, N. Y.*

The recent use of silicone coatings in the glass industry is

quite encouraging. Silicones are members of the polymeric family composed of carbon, silicon and oxygen. They are man-made and do not occur naturally. They provide lubricity and release functions. They are fireproof, so to speak, and do not volatilize readily. They are made both as aqueous and as oil emulsions.

Adequate spraying facilities are necessary for application. In use with feeders, application to delivery equipment has been very advantageous. Carbon deposits have been eliminated and score-mark on gob has been reduced. The occurrence of water-hardness scum is also eliminated by the use of silicones.

Silicones do not decompose and produce a deposit. The concentration of solution is very important. Water-base lubricant is desirable because water acts as a coolant. Improved spraying devices have been developed and are vital to the successful use of these materials. The small quantity of material (0.2%) is very desirable to avoid build-up.

In the lehr, silicones have imparted surface lubricity that avoids scratching and surface deterioration, as well as providing the advantage of water repellency. Resinous silicones and waxy silicones have given best results.

There is belief that the successful coating of the containers is accompanied by reaction between glass surface and coatings. Like all new products, many difficulties of application occur and the future of these materials will be watched with interest.

Silicone Applications in Glass Container Manufacture. *By G. W. Peckham, Chattanooga Glass Co., Chattanooga, Tennessee.*

A brief illustration of the use of silicone application to beverage bottle manufacture was given. The use as a mold release was the principal interest.

It was desired to reduce (1) smoke, (2) dirt and (3) fire hazards. The reduction of cleaning of dirty molds was also desired. Spray nozzles first were found inadequate to carry silicone emulsion. They operated successfully for oil-emulsion, but not for silicones. They were used to coat shears, delivery equipment, moid plates, etc. Because very weak solution is desirable, the silicone was diluted considerably, almost 100%, as received, 70-1 and 100-1 with water.

The objectives have been reached; the molds remain cleaner 7-10 times longer than they did when oil was used. Dirt, smoke and fire hazards have also been reduced. The silicones have proven to be cheaper in the long run. It seems to offer very encouraging results and it may have universal application. It is also possible that even more dilute sprays will be desirable. The water emulsions caused by excessive cooling have caused checking on some mold surfaces. This has been overcome by better atomization of spray and less temperature shock.

The Current Status of Electric Booster Melting. *By L. Penberthey, Penberthey Electromelt Co., Seattle, Washington.*

The subject of electric melting is both old and new. A brief survey of the past and history of electric melting of glass was given. The first patents were issued in 1913, and earlier work was done in Europe. Ferguson, Hitner and Wadman held the basic booster patent in 1934, and they did very little for most of the life of the patent. Improved refractories and other fuel developments have provided improved melting possibilities and have been a distinct aid to electric boosting. First scale booster on container glass was made in August, 1952, at the Northwestern Glass Company, Seattle, Washington.

Electric boosting is a process of adding heat electrically to a normally heated furnace, with heat being liberated within the glass itself. A furnace can be self-deregulatory owing to change in resistance of glass at temperature increases. For this reason, current has to be regulated carefully. The economics of boosting are such that it can be used where other fuel costs are low. Molybdenum is believed to be the best electrode material. About 30 boosters are now being used in the United States today.

Output of extra glass may not be too large. It may be only 10 to 30%, but it is quite valuable because it brings many glass tanks past the "break-even" point and places them in a profitable range. At present, electric boosting is being used in sizes of 100 to 700 sq. ft. tank area. A foreign tank of 1200 sq. ft. is said to be using electric boosting. It has been applied to a great variety of glass, and it is not necessary to have soda in the glass to carry the electricity.

The advantages of electric boosting are many. It is very flexible and can be used by merely turning on the switch. The furnace can operate at lower firing temperatures. It will cut down normal gradient from top to bottom. It will cut down loss of volatile constituents (for instance, boric oxide). Boosting will ease firing problems, such as clogging of checkers and other parts, reduce cost of refractories (because output is greater), extend life of tank. It makes batch charging easier with less clogging at the doghouse. Boosting is said also to use less cullet.

The cost of installation may vary from $12,000 to $15,000, depending upon the size of the operation. The economies are derived by increased production, better glass, etc. The electrode consumption is about 20¢ per ton of glass. Maintenance is low and installations are easy when cold but may be difficult when made hot.

Ease of operation is very simple. It is usually confined to *On and Off* switch, but more elaborate control is desirable. The operation is very dependable. Because it adds to the stable load of power, it is liked by power companies.

Mr. Penberthey believes that the future possibilities are splendid, and the horizons and developments are improving. There is a definite need for greater furnace production to satisfy better machines, lehrs and annealing. Boosting answers the problem of better and increased furnace operation —the bottle neck of the industry today. The flexibility of operation is splendid. The process provides stimulation of control of convection currents and the development of new convection currents. This is a new tool in melting operation that promises to revise our thinking on glass melting.

Control for the Electric Melting of Glass. *By E. A. E. Rich, General Electric Co., Schenectady, New York.*

Electric glass melting places the bulk of the electric energy received at the glass melting electrodes directly into the body of the glass itself. It is almost always used in conjunction with other fuels for melting, such as gas and oil.

If the bulk of the energy needed for actual melting is supplied from electric sources, the process tends to be called direct electric melting, even though a flame blanket may be used over the glass to supply tank losses, etc. If electric energy is used principally as a supplement to the actual glass melting energy derived from more usual fuels, the process tends to be called booster electric melting. Precise distinction between direct and booster melting is not made industry-wide at the present time.

Over-all economics are as follows: (1) More tons per day of glass can be melted. The incremental investment in electric melting equipment, as compared to the investment required for a new tank of conventional design to obtain the increased capacity, may be relatively small, or considerable, depending on the particular changes needed. (2) Better quality of glass can be produced, without necessarily sacrificing production. (3) Longer effective life of certain refractory linings can result for same total tonnage output of melted glass. This is less true for those refractories exposed to higher operating temperatures during electric melting. (4) Better flexibility of pull often occurs by using booster melting.

Ordinary soda-lime glass, with normal proportion of cullet, is said to consume 400-600 kw hours per ton when melted by booster melting. Relative single phase voltages needed for booster melting may be summed up roughly as follows:

Lime Glass	90 volts
Lead Glass	250 volts
Borosilicate	325 volts

Variation in electrical resistance of glass with temperature is great and is another reason why flexibility in voltage available at the electrodes is needed.

As an example for lime glass booster electric melting, some glass manufacturers feel a voltage range of between, say, 150-170 volts is preferred. Least equipment price results by using reduced kva taps between these voltages because the physical size of the transformer is least.

It is known that glass has negative resistance versus temperature characteristics. That is, as glass becomes hotter, its resistance to the flow of electric current becomes less. For example, suppose that constant voltage is applied to a given glass batch. As the current flows through the glass, increased temperature of the glass results, which in turn means increasingly lowered resistance of the glass, which in turn means that since the voltage applied is contant, more current will flow. This causes the temperature to increase still further, and so on, until, in time, a runaway condition may be reached.

A saturable core reactor in series with the load current supplying the electric energy to the glass has an impedance characteristic which is opposite to that of the glass and, if properly selected, helps to give stable operating performance.

Another method of obtaining satisfactory operation in controlling current flow has been found to use an induction voltage regulator equipped with automatic current regulating features. In usual practice, constant current is held in the load circuit supplying the glass. Pronounced temperature changes in the glass take appreciable time to occur. Induction regulators equipped with automatic constant current regulating features can ordinarily easily keep ahead of the inherent tendency of the current to increase as the glass resistance decreases.

Constant current operation inherently tends to hold constant the temperature in the glass. Energy loss in the glass varies directly as the product of the current squared and the glass resistance. If the glass starts to cool, its resistance increases. The constant current regulator will in turn increase applied voltage until the desired current level is again reached. This forces more energy into the glass, thus tending to increase its temperature.

As a practical matter, the time lag between energy input and resulting glass temperature changes by this method is ordinarily long enough that simple manual control may be adequate to maintain stability of current flow within reasonable limits.

Some users of booster melting feel simple tapped transformers are adequate to obtain sufficient voltage range of control of electric booster melting, even allowing for variation of resistance with temperature. If used with adequate metering and protection to the electric equipment and to the personnel involved, such claims appear well founded.

Electrode protection is provided to guard against excessive electrode current overloads. Transformer protection is needed to avoid possible damage from overheating of any winding of any transformer. Short circuit protection of all equipment is best included with the main controller.

Metering of volts and amperes to all electrodes is very helpful to operators. Voltage levels are usually selected by extending primary windings and supplying taps on primary and/or secondary windings of melting transformers.

Actual control of the entire electric melting energy involved is almost always best done by handling the entire load of saturable reactors (or other regulators), plus melting transformers, as though it were a motor starting problem.

The following have been done in order to improve safety and to minimize certain adverse effects: (a) The steel pattern of the supporting structure for the tank is sometimes broken up so as to minimize closed loops of large expanse which might tend to by-pass currents through them. (b) Catwalks, and related structures, may be insulated. (c) Grounding of the tank crown or other parts of the tank proper may be avoided on the premise that this tends to failure of the tank should grounds in the electric booster melting equipment or cables, etc., occur. (d) Equipment should be used that has the same kva output possible throughout quite a voltage range in order to assure the capabilities of getting electric energy into the glass regardless of the voltage needed. If necessary, equipment should be selected which has extreme flexibility of voltage in mind in order to handle lime and lead, and sometimes borosilicate glasses. The wide range of voltages needed for electric booster melting of these glasses is often best obtained by the usual extended tapped transformer primary winding, plus a series parallel switch on the secondary of each transformer to extend the constant kva rating over a larger voltage range, plus a saturable reactor for vernier control of current.

Typical equipments needed were illustrated and shown. Mr. Rich's paper was most informative on the needs and requirements of "electric boosting."

Molybdenum Electrodes for the Glass Industry. *By R. B. Freeman, Westinghouse Electric Corp., Bloomfield, New Jersey.*

Molybdenum has been used for electrodes in glass furnaces since 1943. Iron was used prior to this time. In Europe, graphite has been used with some success, but molybdenum is also being used.

In reviewing the history of molybdenum, Freeman pointed out that it was first used as a wire support in incandescent lamps. In 1925 it found use as an alloying agent in metals. Approximately 90% of present output is used by the steel industry, 5% by the chemical industry and 5% in the manufacture of electrodes. The deposit at Climax, Colorado, is rich, and the United States mines about 90% (excluding Russia). This mine has a very great capacity and should provide ample supply for many years to come.

Molybdenum possesses several outstanding physical properties which make it especially suitable for use as an electrode in the glass furnace. Chief among these are: (1) High melting point, 4750°F. Permits its use at temperatures far above the softening point of common metals. (2) High temperature strength. Exceeds that of any other commercial metal except tungsten at temperatures above 1650°F. (900°C.). (3) High electrical conductivity, 29% of copper. Higher than all other common metals except aluminum, copper and magnesium. (4) Low specific heat, about half that of nickel or steel. Of advantage where rapid temperature changes are desired or for the reduction of temperature gradients in a heated body. (5) High thermal conductivity, about 3 times that of steel; an advantage for heat-transfer purposes. Because of this conductivity and its low specific heat, molybdenum can be rapidly heated and cooled with much lower thermal gradients than obtained with steel. (6) Low coefficient of thermal expansion, about half that of steel; advantageous where elevated temperatures are involved. Means greater dimensional stability and less danger from thermal induced stresses.

The chemical properties of molybdenum of major interest to the glass industry are as follows: (1) High purity, over 99.9%, insures against contamination or discoloration of the glass melt. (2) Resistance to action of molten glass. Molybdenum is attacked very slowly by glass at furnace operating temperatures. (3) Colorless oxide. Any molybdenum which goes into solution as oxide does not discolor

the glass. (4) Oxidation in air may be reduced by (a) painting with water-glass solution, (b) packing around electrode with powdered glass, (c) coating electrode with nickel, aluminum-silicon alloy or molybdenum disilicide.

Practically all molybdenum used by the glass industry is 3/16" thick or greater so that it is necessary to heat the material to a temperature of approximately 1500°-2000°F. in a reducing or neutral atmosphere before any forming operations are attempted.

Large molybdenum parts for the glass industry are normally joined by hot-riveting with molybdenum rivets or by machined molybdenum bolts. Arc welding of molybdenum by the atomic hydrogen and inert gas arc welding processes has been done experimentally but is not recommended for general use at the present time because of the special techniques required.

The quality of molybdenum produced has improved to such an extent in the past 10 years that little difficulty should be experienced in any of the standard machining operations. A majority of the machine shops today use standard high-speed steel tools for this work, but tungsten carbide is preferred by others. In drilling, it is desirable to keep the drill cool, as well as clean, because the steel drill expands about twice as much as the molybdenum. This may result in the drill's seizing and cracking the molybdenum.

Stress Release in Glasses. *By C. J. Phillips, Radio Corporation of America, Camden, New Jersey.*

In 1948, Lloyd Black of the Glass Research Laboratories, Pittsburgh Plate Glass Company, directed a series of experiments to determine the rate at which tempered glass loses its strain when exposed to elevated temperatures for various periods of time. Black's results were so interesting and of such practical significance that attempts were made to develop equations which would predict the loss of stress at higher and lower temperatures and for longer and shorter times.

Black used 12" x 12" x 1/4" plates of Ford City tank glass as specimens. These were tempered in such a manner that the strain was as even as possible throughout the area of the plate and had a value of approximately 3200 Mu per inch which we commonly designate as full temper.

The tempered plates were subjected to temperatures between 425°F. and 970°F. for intervals of 3, 23 and 119 hours. After the plate had remained at a given temperature for a predetermined time, it was removed from the furnace and when cool the strain was measured through the four corners. The plate was again inserted in the furnace and allowed to remain for the next time interval and the process repeated. Each sample, therefore, was heated and cooled three times. Different results would undoubtedly be obtained if one sample were heated 3 hours, another 23 hours, and the last 119 hours, without intermediate observations. Another difficulty is that the decay is so rapid at the higher temperatures, much of the double refraction has disappeared before the glass can be heated to that point. Nevertheless, the procedure was entirely straightforward, and perhaps of greater practical value than it would have had under more idealized conditions.

The *empirical* formula shown duplicates Black's observations quite faithfully:

$$\text{Log } F = \text{Log } F_0 - \frac{K}{A} \log (Bt+1)$$

Here F = stress (kg/mm²) at time t (hours).

F_0 = initial tempering stress, 5.0 kg./mm² central tension, so log F_0 = 0.7 approximately

$\frac{K}{A}$ = quantity varying with temperature

B = quantity varying with temperature

This equation has values at two typical temperatures:

At 895°F. (480°C.) Log F = 0.7 − .58 log (13t + 1)

At 616°F. (324°C.) Log F = 0.7 − .043 log (1.5t + 1)

A physical basis for this formula came from the work of Littleton and Lillie who emphasized the tremendous importance of the "thermal history" of the glass. They found that a rapidly cooled rod or fiber could have a temporary viscosity as much as one hundred times less than for a slowly cooled rod or fiber of the same kind and size. In effect, this means that the conditions of a higher temperature state can be "frozen" in glass to a degree depending upon how rapidly it has been cooled or, in other words, depending upon how much time it has had in which to try to reach a condition of equilibrium. When such glass is reheated, it may take hours, days or even years (depending upon temperature) to remove the effects of this frozen-in condition.

Black's "full temper" required a degree of chilling so rapid that a higher temperature state is "frozen" in the glass. To fix the initial viscosity curve more accurately, the investigator must appeal to the experimental results themselves, since there are no direct viscosity measurements on the tempered samples. For example, by considering the stress release at the usual strain point (517° C.), the investigator can establish 493° C. as a roughly equivalent temperature for the tempered glass.

The generality of the empirical equation developed here will be extended if it can be shown to apply to the pioneering data of Littleton and Lillie. Their stress release data were expressed in terms of birefringence (mu/cm) and the published graphs are so small that accurate reproduction is difficult. The data at 460° C. are quite well represented by:

$$\text{Log } \delta \text{ (delta)} = 3.3 - .935 \log (.36\,t + 1),$$

where δ (delta) = birefringence (mu/cm). If this be converted to actual stress in kg./mm², for comparison with other equations in this report, we have

$$\text{Log } F = 0.9 - .935 \log (.36\,t + 1).$$

It would be extremely interesting, from a theoretical point of view, to extend this kind of work in several directions: (1) By exposing each sample for one length of time only. (2) By gathering comparative data on fibers of the same glass, with simultaneous measurement of the viscosities at each time. (3) By varying the initial degree of temper and the reheating rate. (4) By determining how accurately certain equations fit the (a) long-time data of Morey on Pyrex brand glass and (b) original data of Adams and Williamson. (5) By establishing, with this additional evidence, the true meaning of K and A, on the basis of the present picture of the atomic structure of glass.

A banquet was held at the Deshler-Hilton Hotel in downtown Columbus on Thursday evening, December 2. Professor F. V. Tooley, of the University of Illinois, presided. Dr. Samuel Renshaw, Department of Psychology, The Ohio State University, gave a most interesting talk on recent work in his department related to improvements in reading, improvements in comprehension, etc. Dr. Renshaw is remembered for his most important work during World War II, in which trainees were carefully trained and schooled in the art of identifying enemy aircraft. This contribution was most helpful and of profound importance to the war effort.

Dr. Renshaw pointed out that reading is one of the most important accomplishments of mankind; it is of fundamental importance to our existence and of vital importance to our ability to comprehend and provide productive effort. A lot of people "look but can't see." They fail to comprehend, certainly differ in capacity of comprehension. The latter factor is capable of improvement as has been definitely shown by Dr. Renshaw's work.

The functions of mankind are most complicated. For instance, the human head contains 12 billion nerves and

(*Continued on page* 50)

INDUCTION REGULATORS OR SATURABLE REACTORS– Which is Best for Electric Melting of Glass?

By C. R. Olson, Industry Engineering
Westinghouse Electric Corporation, East Pittsburgh, Pennsylvania

Because the electrical characteristics of glass change as its temperature rises, the electric melting of glass poses several problems not usually found in other electric furnace operations. Basically, these problems involve a regulation of current to obtain a suitable heating pattern. For instance, the ideal power supply system should supply a constant power input to heat the glass, yet should reduce the power considerably once the desired temperature is reached.

The two major types of electric power supplies for glass melting are the saturable reactor and the induction regulator systems. Both are not equally good for every application, so a study based on (1) first cost, (2) maintenance, (3) operation, (4) efficiency and (5) power factor has been made. No consideration was given to those applications where electric heat is used only as a supplement to the prime source of melting heat.

Glass at room temperature can be classified as an electrical insulator. However, as its temperature increases, it loses its electrical insulating properties gradually until as a liquid it is a fairly good conductor of electricity (Fig. 1).

The change in resistivity of glass with temperature is very rapid as a typical curve of electrical resistance versus temperature for one particular soda-lime glass illustrates. Over the temperature range of 1400 to 2000 degrees F., the resistivity drops from 90 to 9. ohm-cm. Mathematically, this represents resistance varying inversely as the eighth power of temperature. Although the resistivities of different glasses differ widely, the same general shape of curve still applies.

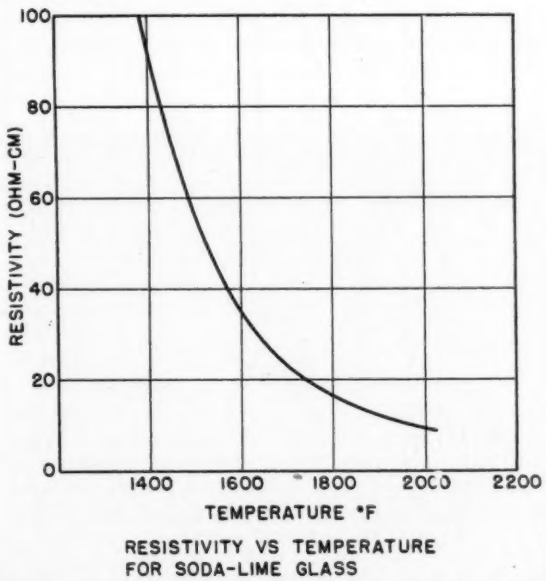


Fig. 1. Resistivity of soda-lime glass, as well as other glasses, decreases with increase of temperature.

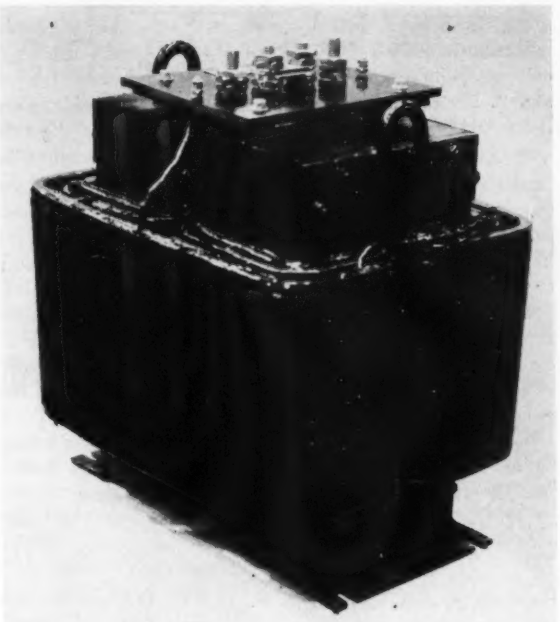
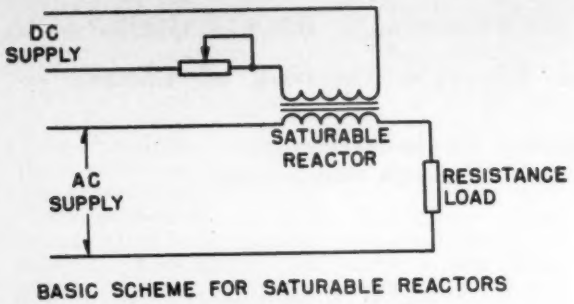


Fig. 2. The typical saturable reactor looks very much like an ordinary transformer and, like a transformer, is a completely static device.

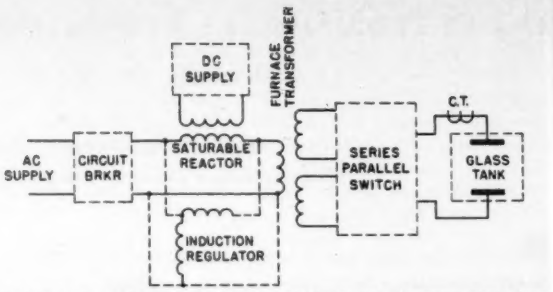
This negative temperature coefficient of glass can affect electrical glass melting operations in two ways: the current tends to concentrate in a channel between the two electrodes to heat this channel more than the entire glass batch; and because of the negative coefficient and the fact that current increases as resistance decreases, the current concentrates to an even greater extent and causes the danger of hot spots. However, this problem can be solved by proper design of the furnace and electrodes. The negative temperature coefficient actually is an aid to glass melting because it can be helpful in regulating the temperature of the glass melt. If a constant current is maintained, the system tends to become self-regulating since an increase in temperature is accompanied by a lowering of resistance and consequently a decrease in power or heat input. Conversely, a decrease in temperature causes a gain in resistance with a consequent rise in heat input. Thus a stable condition is achieved.

Certain general requirements must be met by an electrical supply system for electric glass melting applications. More power is required to raise the temperature of glass than to hold it constant. Therefore, when the heating of a glass melt is begun, a relatively large amount of heat must be put into the glass to raise the temperature to the desired operating point. After the desired temperature is reached, the power input can be reduced to a value sufficient only to hold this temperature. These facts indicate that the electrical power supply system used should be



BASIC SCHEME FOR SATURABLE REACTORS

Fig. 3. Basically, the saturable reactor is a variable reactance in series with the electrical load. In this case, the glass furnace.



SINGLE-LINE DIAGRAM FOR SATURABLE REACTOR AND INDUCTION REGULATOR CONTROL SCHEMES

Fig. 5. To get maximum utilization from either a saturable reactor or an induction regulator, a furnace transformer usually should be used.

capable of supplying a high voltage with relatively low current under low temperature starting conditions. Then as the operating temperature is approached, it should furnish a low voltage and a high current. The voltage and current are then both reduced for holding the temperature.

In addition to meeting the above conditions, the power supply system must be able to prevent automatically a runaway condition. This can occur if a constant electrode voltage is maintained without any limit being placed on the current. Then, as the temperature rises, the resistance drops, the current and power increase, the temperature again rises and the cycle continues. This runaway condition can cause local hot spots in the molten glass, severe damage of the electrodes, damage to the refactory material, and damage to the associated electrical equipment. This can be prevented by supplying a regulated current or by using electrical equipment which places a ceiling or limit on the electric current to the furnace.

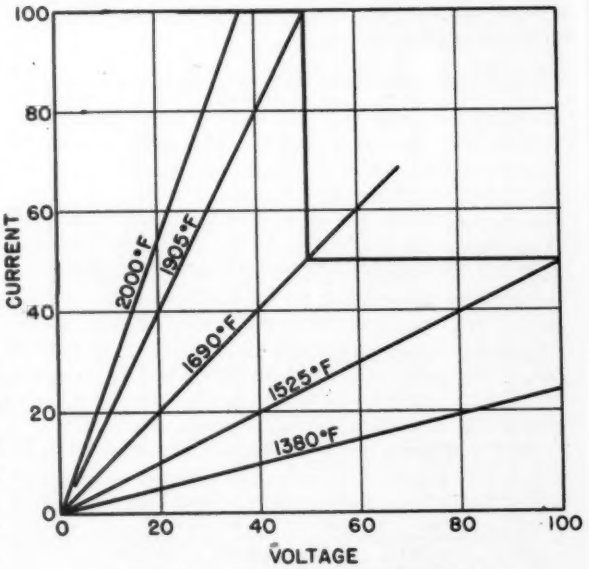
Fig. 4. The induction regulator acts as a transformer with a rotatable secondary winding.

Saturable Reactor and Inductive Regulator

A typical saturable reactor looks very much like a transformer and, like a transformer, is a completely static device (Fig. 2). Basically, it is simply a variable reactance which is placed in series with the electrical load (Fig. 3). The amount of current flowing in the d-c winding determines the effective reactance and consequently varies the amount of current flowing in the system. It is, in effect, a means of varying the voltage which appears across the furnace electrodes (the resistance load). As such, it is used to vary the power input to the glass melt.

The word "regulator" in "induction regulator" is actually a pseudonym because for glass melting service the device is non-automatic, being controlled by an external current or temperature regulator. Except for the substitution of the induction regulator, the system is basically the same as that for the saturable reactor. The induction regulator acts as a transformer with a rotatable secondary winding. By rotating this secondary winding mechanically, the induced voltage can be varied and made to add to or subtract from the supply system voltage. Any amount of voltage variation can be obtained by proper selection of the secondary winding voltage (Fig. 4).

To get the maximum utilization from a saturable reactor or an induction regulator, it is often advisable to use a furnace transformer. This is also frequently required to supply an odd voltage necessitated by the furnace design. If taps or serious-parallel windings are used on this transformer, more power is available over a wider temperature or voltage range. For the purposes of this article,



AVAILABLE CURRENT & VOLTAGE & GLASS RESISTANCE LINES

Fig. 6. Voltage and current available when a furnace transformer is used in conjunction with an induction regulator or saturable reactor

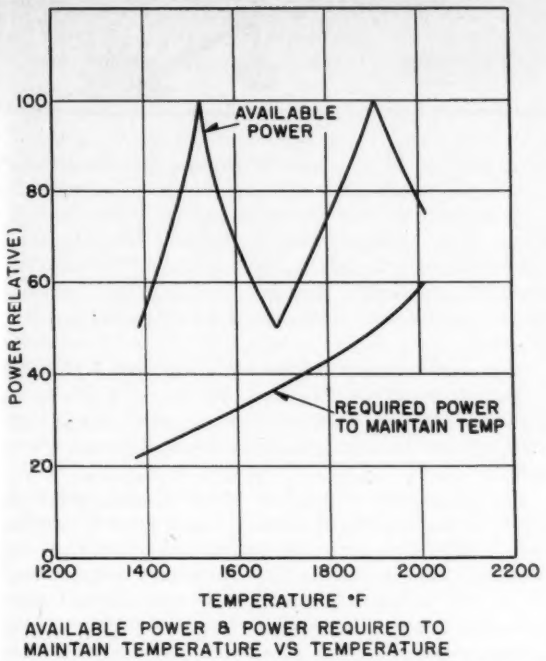


Fig. 7. Available power over 1380 to 2000 degrees F. range.

it has been assumed that a furnace transformer is used which has a single primary winding and two separate secondary windings. These windings can then be connected either in series or in parallel (Fig. 5).

A graph of the voltage and current available with the furnace transformers connected into the complete system is shown in Fig. 6. The current remains constant from 25 to 50 per cent voltage, a variation which is obtained with the saturable reactor or induction regulator by connecting the transformer secondary windings in parallel. If the secondary windings are connected in series, the maximum output current drops to 50 per cent of the previous maximum, and this value of current is obtainable from 50 to 100 per cent voltage. Also shown on this curve are the various resistance lines at temperatures from 1380 to 2000 degrees F. for the typical soda-lime glass mentioned earlier. The available power over this same range is shown in Fig. 7. The number of peaks and the ratio of maximum to minimum power can be varied by design of the furnace transformer. Also indicated is an assumed curve of the power required to maintain the specific temperature. No overlapping of the two ranges is shown for purposes of simplification. Such overlapping permits operation at or near switching point without incessant switching.

The available current over the specified voltage range and the available power over the temperature range are identical for either the saturable reactor or induction regulator system. This is based on the assumptions that the current rating of both the induction regulator and the saturable reactor are the same, that the furnace transformers have the same kva rating and that the regulator is designed for 33⅓ per cent buck or boost about the supply system voltage. These assumptions were made so that a fair comparison could be made between these two systems.

The simplest type of control for either of the two basic systems is manual. For the saturable reactor a small d-c supply is required. A simple manual rheostat is used to control the amount of d-c current which in turn controls the a-c current. For the induction regulator system a simple "raise-lower" switch is used to change the electrode voltage. Current limit protection may not be necessary for the saturable reactor system since it is inherently a current limiting device. However, the induction regulator is not, and consequently a current relay should be used to prevent a runaway and the possible damages mentioned earlier.

Automatic regulators used with saturable reactors may be of two basic types: (1) current regulator (Fig. 8) or (2) temperature regulator (Fig. 9). As discussed previ-

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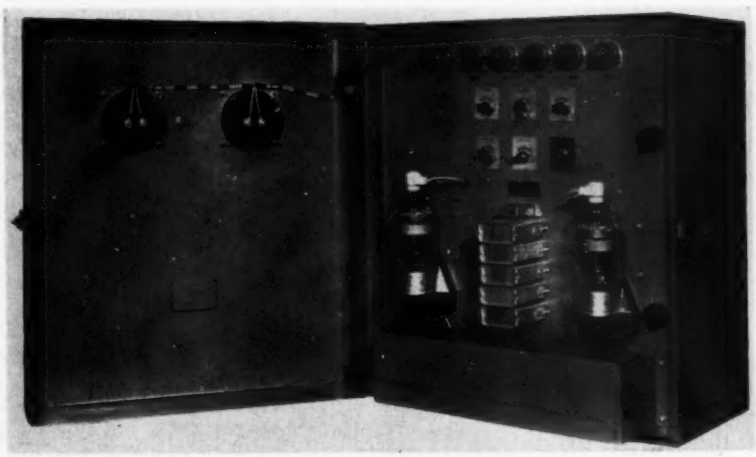


Figs. 8 and 9. Automatic regulators for use with saturable reactors may be of two types: current regulator or temperature regulator.

Inventions and Inventors

Feeding and Forming

Glass Feeder Plunger-Operating Mechanism. Fig. 1. Patent No. 2,685,765. Filed May 23, 1951. Issued August 10, 1954. One sheet of drawings. Assigned to Corning Glass Works by Frederick A. Dahlman and Donald J. Tingley.

The outline of cam 60, Fig. 1, governs the rate of speed and the extent of movement of the spool 41, which in turn regulates the flow of fluid to the respective ends of cylinder 16 and from the ends of such cylinder in a manner to move the cylinder in a direction and at a rate of speed in accordance with the cam contour. The cylinder 16 during such movement, by means of its linkage with the tracer valve, moves the spool 41 in the reverse direction to that in which it is being moved by the cam 60 and at such rate that the original counterbalance is reestablished substantially immediately following discontinuance of movement of the spool by cam 60.

The operating characteristics of the plunger 10 are dictated by the outline of the cam used and that, accordingly, by selection of the proper cam and suitable adjustment of screws 56 and/or 69 and/or by changing the pivot point 68, any of a practically unlimited variety of plunger-operating characteristics can be obtained. Obviously, the plunger-height and plunger-stroke adjustment features are employed to make the operation of the plunger compatible with the gob characteristics it is expected to produce with any particular cam. This invention enables gob formation to be readily accomplished and maintained with an unusually high degree of accuracy. The desired shape of the gob can also be controlled within a very narrow tolerance with the result that a wider range of shapes can be satisfactorily pressed and the selection of commercially suitable ware can be materially improved.

The patent contains 5 claims and the following references were cited: 1,119,324, Sprater, Dec. 1, 1914; 1,500,685, Roberts, July 8, 1924; 1,537,962, O'Neill, May 19, 1925; 1,742,946, Bertram, Jan. 7, 1930; 1,746,913, Stenhouse, Feb. 11, 1930; and 2,246,461, Cannon, June 17, 1949.

Glass Mold Having A Detachable Two-Part Insert. Fig. 2. Patent No. 2,683,332. Filed January 5, 1953. Issued July 13, 1954. Two sheets of drawings. Assigned to Dutalite Company by Lawrence J. Litalien and Joseph Duthaveck.

The object of this invention is to produce a glass forming mold constructed of exterior cast iron mold sections having detachable wear-resistant inserts, whereby a long mold life may be obtained. It further provides a mold which will be standard for a plurality of sizes of glassware, and also possesses high thermal conductivity, low thermal expansion, high resistance to grain growth and high resistance to wear.

In the operation, the inserts 18 are pushed down into the two-part mold body members 10, 11 (not shown) as far as they will go, until they strike the stops 24, 25. To complete the assembly of the mold, a rectangular neck ring made of two parts 39 and 40 (not shown) and having a central aperture 41 is placed at the open or upper end of the two-part mold, as shown in Fig. 2. The bottom of the mold is then closed by inserting the detachable rectangular bottom plate 28 upwardly into the body members 10, 11. It is to be understood that after a glass gob 37 has been partially blown in a "blank" mold, not shown, it will be inverted and transferred to the "blow" mold herein disclosed with a partially-blown cavity 38 formed within the gob 37. The remainder of the glass blowing operation takes place within the cavity 42 of the blow mold, producing an article of hollow glassware W having uniform thickness and conforming closely to the shape of the interior of the insert sections 18 and 19 (not shown), respectively.

The patent contains 6 claims and the following references were cited: 1,559,394, Williams, Oct. 27, 1925; 1,609,708, Gilligan, Dec. 7, 1926; 1,894,243, Rohrich et al., Jan. 10, 1933; 1,910,015, Homand, May 23, 1933; and 114,815, Germany, Nov. 9, 1900.

Mount Loading Guide and Bulb Centering Device. Pat-

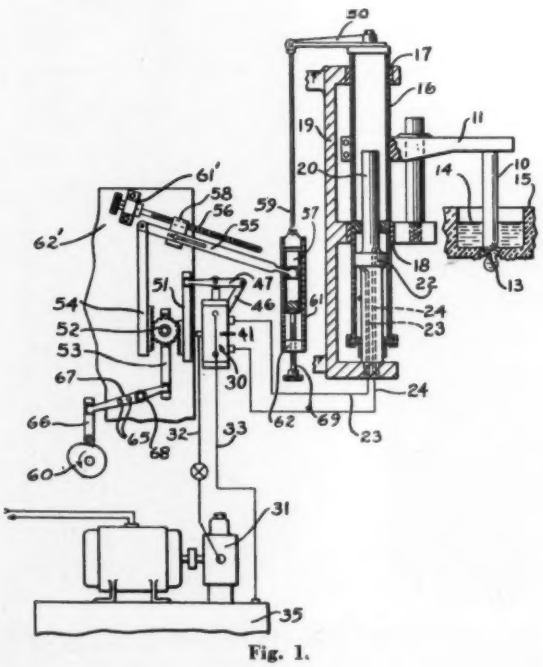


Fig. 1.

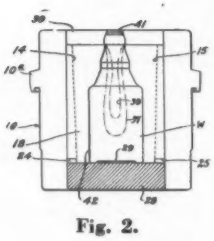


Fig. 2.

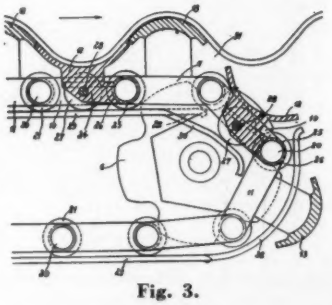


Fig. 3.

ent No. 2,685,762. Filed October 26, 1951. Issued August 10, 1954. Three sheets of drawings (none reproduced). Assigned to Westinghouse Electric Corporation by Daniel Mullan.

This invention relates to sealing machines for incandescent lamps, electronic tubes and, more particularly, to a mount loading guide and a bulb centering device for a sealing head on a sealing machine. The automatic mount guide comprises two arms pivoted on a platform bracket connected by a link and normally separated by a coiled spring. A roller attached to one arm is provided for engagement with a cam track having inclined ends adjacent to the unloading and loading stations. Engagement of the roller on this track closes the pivoted arms above the mount pin, thus providing an inverted conical guide for the convenient, accurate and rapid insertion of the mount tubulation into the pin. Its location directly above the mount pin insures an axially straight mount on the pin.

The bulb-centering device comprises a pair of bulb centering arms rotatable horizontally by a pair of spur gears, the driver gear of which is pinned to a vertically pivoted arm having a roller on its upper end for engagement with a cam track and a recovery counterweight affixed by a counterweight arm. The sealing spindles or heads rotate continuously in the path of the sealing fires at all times except in the seal molding, cooling, unloading and loading stations. The machines operate at high speed and the heads index from station to station in a matter of seconds. An object of the invention is the elimination of operator contact with the heated mount pins of an automatic sealing machine head during mount loading.

The patent contains 7 claims and the following references were cited: 1,628,410, Koning, May 10, 1927; 1,780,618, Fleischmann, Nov. 4, 1930; 2,135,290, Loebe et al., Nov. 1, 1938; 2,143,708, Muller et al., Jan. 10, 1939; 2,153,370, Donovan et al., Apr. 4, 1939; and 2,494,870, Greiner, Jan. 17, 1950.

Glass Compositions

Photosensitively Opacifiable Glass. Patent No. 2,684,-911. Filed August 30, 1951. Issued July 27, 1954. No drawings. Assigned to Corning Glass Works by Stanley D. Stookey.

This invention relates to photosensitively opacifiable glass; that is, glass in which exposure to short-wave radiations, such as ultraviolet radiations, brings about an invisible change, as a result of which irradiated areas are capable of heat-developed opacification while non-irradiated areas remain substantially unchanged on heating. The opacified portion of such a glass is more soluble in dilute hydrofluoric acid than in the clear unexposed portion.

In an article made of such glass, the opacified image is three-dimensional and may, if desired, extend completely through the glass. Its removal, therefore, leaves a corresponding depression or hole in the glass. Designs and filigrees of various sorts, including those previously either impossible to achieve or requiring long and laborious mechanical grinding, can by such means easily and quickly be carved in glass. The following compositions in weight percentage illustrate glasses falling within the scope of this invention:

	I	II	III	IV	V	VI	VII	VIII	IX
SiO_2	77.5	85	82.5	82.5	80	79	72.5	80	81.5
Li_2O	12.5	10	12.5	12.5	12.5	9	12.5	12.5	12
Na_2O	——	——	2.5	——	7.5	2	——	——	——
K_2O	——	——	——	2.5	——	2.5	5	5	3.5
Al_2O_3	10	5	2.5	2.5	——	7.5	10	2.5	3.0
AgCl	0.002	0.002	0.006	0.006	0.002	0.002	0.002	0.002	0.002
CeO_2	0.02	0.02	0.003	0.02	0.02	0.02	0.02	0.02	0.02

The patent contains 13 claims and the following references were cited: 2,370,214, Walker, Feb. 27, 1945; 2,377,062, Adams, May 29, 1945; 2,515,939, Stookey, July 18, 1950; 2,515,940, Stookey, July 18, 1950; and 2,515,942, Stookey, July 18, 1950.

Glass Composition. Patent No. 2,685,526. Filed June 15, 1951. Issued August 3, 1954. No drawings. Assigned to Glass Fibers, Inc. by Dominick Labino.

This invention relates more particularly to a glass composition for the manufacture of glass fibers. A glass composition capable of satisfactorily producing strands or fibers of the order of 10-20 millionths of an inch thickness must satisfy the following particular requirements: (1) the glass must have, when molten, a high viscosity. By this is meant that the interfacial tension must be high, (2) the molten glass must have a low surface tension which permits it to be drawn out into long thin strands, (3) the glass composition must have a low softening point, preferably in the range of 1800 to 1900° F., (4) the glass must have a high resistivity to chemical attack.

A fine glass fiber having substantially the following composition by weight has given good results:

	Per cent
SiO_2	54.3-54.75
CaO	6.35-7.43
MgO	3.98-4.12
B_2O_3	10.2-10.5

more than 9 per cent and less than 10.5 per cent of an oxide selected from the group of copper and lead oxides, the balance being essentially aluminum oxide.

The patent contains 7 claims and the following references were cited: 1,529,259, Locke et al., Mar. 10, 1925; 2,100,391, Grimm et al., Nov. 30, 1937; 2,394,493, Schoenlaub, Feb. 5, 1946; and 2,517,459, Armistead, Aug. 1, 1950.

Sheet and Plate Glass

Apparatus for the Continuous Production of Corrugated Sheet Glass. Fig. 3. Patent No. 2,682,133. Filed February 11, 1953. Issued June 29, 1954. One sheet of drawings. Roger Guilleminot.

Apparatus is described for the continuous production of corrugated glass sheet. Extending beneath the rollers 27, as shown in Fig. 3, is a specially provided runway 29

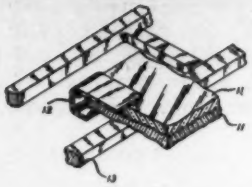


Fig. 4.

separate and distinct from the runway 22 for rollers 21. Throughout the straight part of the path of motion of the chain, the runway 29 extends in a common horizontal plane with the runway 22. Adjacent the drum 6, however, the runway 29 is inclined, as shown at 30, over a suitable length extending beyond the end of runway 22.

In the horizontal flight of the chain, wherein the ways 22 and 29 lie on a common level, the elements 12 and 13 are juxtaposed and define an uninterrupted undulating surface over which the glass sheet spreads, is shaped and sets to the desired shape.

As the chain passes over the drum 6, the convex elements 13 unitary with the segments 11 rotate without any relative displacement between. The concave elements 12, on the other hand, are guided by their rollers 27 which follow the inclined portion 30 of the runway 29, so that they are caused to pivot about the front axes of the segments 10 and are lowered a short distance. They are thus caused immediately to disengage the glass sheet and are separated whereby the sheet is enabled to continue on its path of travel without interference from the rear edge of the concave element 12. The relative opening between the contiguous two elements 12 and 13, which necessarily occurs at 31 (Fig. 3) as the chain passes over the drum 6, does not result in any objectionable action upon the glass sheet which at that time is in hardened condition.

The patent contains 5 claims and the following references were cited: 972,433, Blackmore, Oct. 11, 1910 and 2,590,768, Guilleminot et al., Mar. 25, 1952.

Glass Bending. Fig. 4. Patent No. 2,683,334. Filed July 16, 1952. Issued July 13, 1954. One sheet of drawings. Assigned to Ford Motor Company by Ormund E. Rugg and Robert L. Woehrle.

An improved procedure for the production of laminated, bent, vehicular windshields is shown. Fig. 4 illustrates the structure and application of clips 12. These clips are roughly shaped to resemble a capital "L" and slipped over the edges of glass sheets 11. The most satisfactory material for the manufacture of these clips 12 has been found to be half hard aluminum sheet about twenty thousandths of an inch thick. These clips are applied with the long side uppermost and with the short side clearing rail 13 upon which the glass rests when it assumes its final shape. The exact location of these clips longitudinally of the glass sheet is not critical except that they should be well removed from the end sections and should not be aligned with each other so that any stress in the glass induced by their presence may not be concentrated. During the actual bending process, the glass sheets are highly stressed and almost certainly are unequally stressed. These clips serve to distribute or equalize the stress between the two sheets of glass. The use of these clips has resulted in a lowering of glass breakage in the lehr from twelve per cent to less than four per cent.

The patent contains 4 claims and the following references were cited: 2,003,383, Miller, June 4, 1935; 2,261,023, Galey, Oct. 28, 1941; and 2,518,896, Jendrisak, Aug. 15, 1950.

Method for the Production of Formed Glass Articles. Patent No. 2,682,730. Filed February 13, 1950. Issued July 6, 1954. Two sheets of drawings (none reproduced). Nicolai J. Rossen.

A method of bending glass sheets is shown. A glass sheet or plate is placed in a mold and, together with the latter, subjected to preliminary heating in a pre-heating zone and then transferred to a heating zone where the glass is heated to such a temperature that it becomes so soft that it sinks down into the mold to rest against its walls. A maximum bending of 40% is effected.

The main feature is the direct transfer of the molds from the oven space where bending takes place, to the cooling chamber in which the glass is evenly and slowly cooled at the range of temperature producing the stresses, the range of temperature lying between 500° and 300° C. for the ordinary glasses, in connection with the use of the special molds. This principle offers special advantages in production of glass bowls, dessert plates, ash trays of glass, glass armatures for electrical lighting bodies and similar formed articles of glass, where it is of great importance that stresses do not occur in the glass, and that conditions may be created for a rational and quick mass production.

The patent contains 3 claims and 16 references were cited.

Miscellaneous Processes

Burner for Coating Hollow Glassware. Fig. 12. Patent No. 2,679,821. Filed April 14, 1950. Issued June 1, 1954. Two sheets of drawings. Assigned to General Electric Company by Robert A. Kuebler.

(*Continued on page* 52)

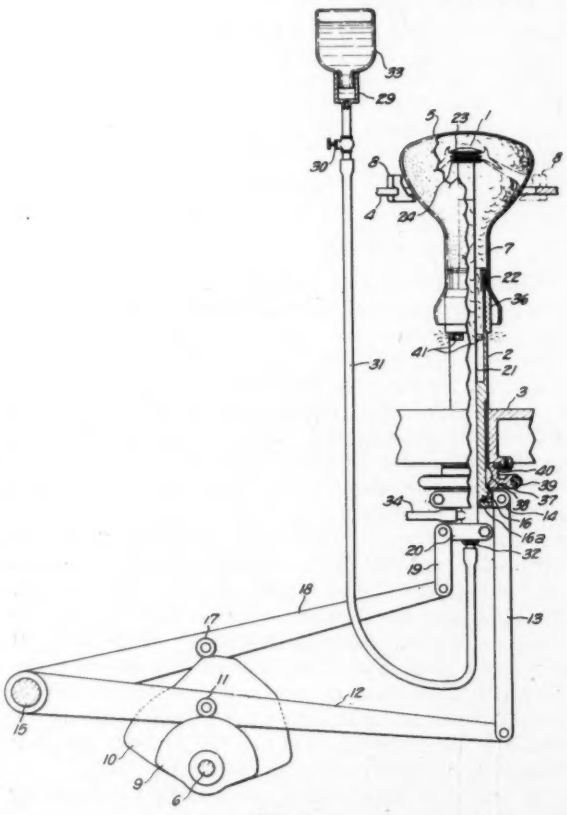


Fig. 5.

Influence of Boric Oxide . . .

The technical value of boric oxide, both as a flux and as a constituent which influences favorably many important physical properties of glasses, was already established by the early years of this century, but at that time the relatively high cost of borax prevented its use in container and flat glass compositions. Not until between 1920 and 1930, when substantial reductions in price took place, was borax tried as a batch constituent by a considerable number of glass container manufacturers. The results were widely acknowledged to be beneficial, particularly in increasing the melting rate, and, therefore, the productivity of the furnace. The gain resulting from increased output much more than offset the cost of borax.

It was established that the addition to the batch of quite modest amounts of borax (sufficient, for example, to give from 0.5 to 1.0% boric oxide in the glass) does markedly stimulate the rates of melting and refining, as well as exercising favorable effects on those chemical and physical properties desirable in glasses used for containers.

During the past 20 years, progressive changes in glass melting procedures have tended to obscure the function of borax as a flux. For instance, there has been a steady rise from 1400° to 1500°C. (and even higher) in the melting temperatures maintained in glass melting furnaces. Such higher temperatures in themselves accelerate substantially the rate of melting and, in the absence of information based on controlled tests, the advantage of borax at these higher melting temperatures is naturally questioned. Further, the introduction into batch mixtures for container glass of small amounts of other known fluxes, in particular barium compounds and fluorides, has complicated the problem of ascertaining whether or not boric oxide, if also present, still bestows any advantage of its own. It was the object, therefore, of work reported by Allison and Turner in the June 1954 issue of the *Journal of the Society of Glass Technology* to provide quantitative data on the value of small additions of boric oxide to glass melted under today's conditions.

Seven such glasses were selected: six for container glasses and one for sheet glasses. The calculated chemical composition of these parent glasses are given in Table I. The range of B_2O_3 in the derivea glasses was 0—2.5%, substituted over-all. In all, 29 glasses were studied. The meltings were carried out in platinum-rhodium crucibles (to eliminate corrosion effects) in a town-gas-fired furnace fitted with arrangements for the strict control of the gas and air supplies. Measurements of melting and refining rates (the latter in terms of visible bubbles per 100 c.c.) were carried out at 1400°, 1450° and 1500°C., with additional meltings at 1425° and 1475° in special cases. Measurements of the viscosity of all the glasses were carried out over the temperature ranges 525°—700° and 900°—1400°.

Chemical composition control was exercised, not only by precise analysis of all the glasses, but also of volatilization during the drawing of glass fibers and during the high-temperature viscosity measurements. The results obtained (presented in the form of numerous charts and tables; the original paper should be consulted for the detail) lead to the following general conclusions:

(1) The melting rate of the batch mixtures, as determined by the time between the addition of the last charge and the disappearance of all solid particles, was progressively increased as the amount of B_2O_3 was raised. The stimulus varied with the composition of the parent glass, being greatest in the case of the simplest glass: 74.2% SiO_2, 8.2% CaO, 17.1% Na_2O (actual analyzed composition) and only slight in the case of the glass of approximate % composition: 73 SiO_2, 0.5 Al_2O_3, 10.5 CaO, 2.2 MgO, 13.2 Na_2O and 0.2 K_2O.

(2) The increase in melting rate is not proportionate to the amount of B_2O_3 present. In three series of glasses (base types I, II and VI), the greatest effect is brought about by the first 0.5% of B_2O_3, whereas in three other series (base types III, IV and V), the effect is proportionate up to 1%.

TABLE I

Base Glass No.	SiO_2	Al_2O_3	CaO	MgO	Na_2O	K_2O	BaO	F_2	Base Type
S30	73.6	....	8.5	....	17.8	....	....	....	I
S35	72.8	2.0	7.9	....	16.1	1.1	....	....	II
B1	73.0	2.0	8.5	2.0	13.4	1.1	....	....	III
B4	73.0	2.0	9.0	2.0	12.9	1.1	....	....	VI
B7	73.0	2.0	8.5	2.0	12.9	1.1	0.5	....	V
F.35A	73.5	2.0	8.8	....	14.3	1.0	....	0.5	IV
S175A	72.4	0.4	10.9	2.3	13.8	0.2	....	....	VII

TABLE II

Comparison of Seed Count (Refining Time), Viscosity (η) at 1400°C. and Temperature Corresponding to log $\eta = 2.0$*

Glass Type	% B_2O_3**	Seed Count	Log η at 1400°C	Temperature at Log $\eta = 2.0$
I	0	76	2.09	1440°C
	0.5	69	2.00	1400
	1.0	56	1.95	1375
	2.5	55	1.88	1343
II	0	80	2.03	1410
	0.5	63	1.99	1402
	1.0	46	1.97	1390
	2.5	16	1.92	1368
III	0	153	2.37	1560
	0.5	120	2.29	1535
	1.0	100	2.23	1505
	2.5	60	2.15	1465
IV	0	139	2.15	1455
	0.5	118	2.10	1440
	1.0	100	2.07	1430
	2.5	61	2.03	1408
V	0	144	2.22	1505
	0.5	127	2.13	1457
	1.0	100	2.07	1430
	2.5	69	2.03	1400
VI	0.45	80	2.23	1545
	0.90	63	2.18	1510
	1.4	46	2.16	1485
	2.5	30	2.10	1460
VII	0	77	2.03	1415
	0.7	51	2.02	1412
	1.4	40	2.02	1408
	2.5	31	1.95	1375

*This is the S. English correlation; namely, that the viscosity (η) at the refining temperature is log $\eta = 2.0$.
**Theoretical addition.

(3) Based on the residual seed present per 100 c.c. of glass, the refining rate, which is the important factor to be considered in preparing commercial glasses, is progressively increased in all cases with increase of B_2O_3 from 0 to 2.5%. It is of interest to note that whereas the effect on the melting rate was the highest in the case of the glass of simplest composition (type I), the effect on the refining rate of this was less than that on all the other glasses. Moreover, the glass (base type VIII), the melting of which was least assisted by B_2O_3, responded in a marked degree in the refining stage.

(4) The conclusions drawn from melting experiments about the progressive increase in the refining rate of all glasses when the B_2O_3 was increased from 0 to 2.5% were corroborated by the study of the temperature at which the viscosity of each glass became log η=2.0. This data is given in Table II.

(5) The stimulating effect of B_2O_3 on the melting rate of the batch mixtures occurred not only when melting at 1400°, but at all temperatures over the range 1400°—1500°. With the simple soda-lime-silica glass (I), the "B_2O_3 coefficient of melting rate" was lower at 1500° than at 1400°, whereas in four other glasses (base types II, IV, V and VI), the effect was either, or nearly, as great at 1500° as at 1400°. With all seven glasses, however, the "B_2O_3 coefficient of melting rate" reached a maximum value at 1450°. It was possible from the curves obtained by plotting melting and refining times against the amount of boric oxide present in the final glass to deduce a simple quantitiative measure of the effect of increasing the boric oxide content. The measure employed were the ratios $M_o/M_{0.5}$, $M_o/M_{1.o}$, etc., where M_o is the melting time determined when no boric oxide was present, and $M_{0.5}$, $M_{1.5}$, etc., when 0.5%, 1%, etc.. of boric oxide had been introduced. This measure was termed the "B_2O_3 coefficient of melting rate."

(6) The refining rate for all proportions of B_2O_3 between 0 and 2.5% increases continuously with temperature from 1400° to 1500° in the case of all the glasses studied.

(7) In glasses containing 0.5% BaO (type V) or 0.5% F_2 as CaF_2 (type VI) as refining agents, addition of B_2O_3 still further increases the rate of melting and refining. In this connection, a subsidiary research is now in progress with the object of making a direct comparison of the relative effects of 0.5% of each of the three fluxes BaO, F_2 and B_2O_3.

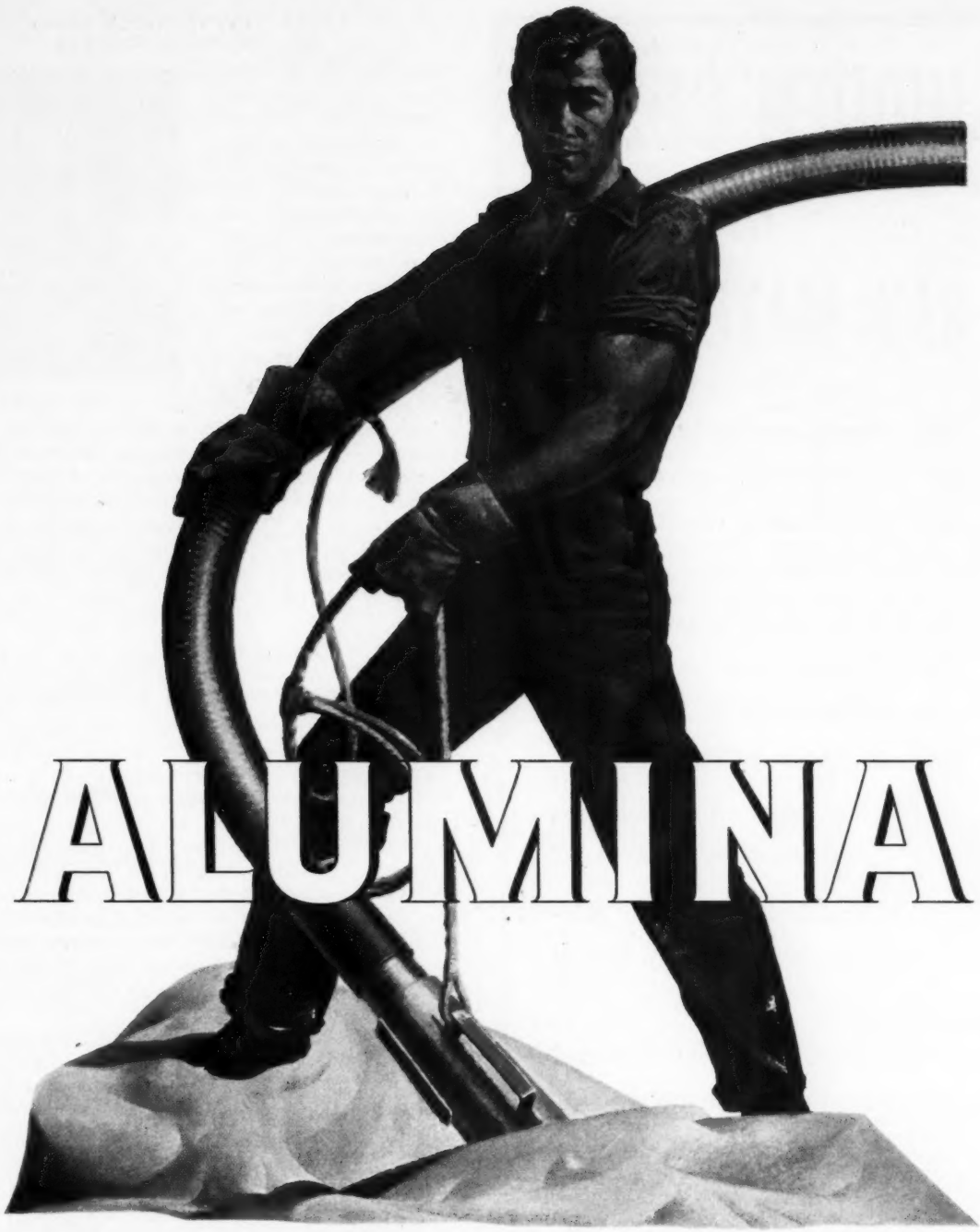
(8) The addition of boric oxide lowers the viscosity of all the glasses progressively within the viscosity range log η=2.0 to log η=7.6, which implies that a given shaping operation in the manufacture of glassware can be

(*Continued on page* 52)

Table III

The Effect of Added Boric Oxide on the Viscosity and Temperature of Container Glasses During Machine Working

				% Boric Oxide Added					
				0.5		1.0		2.5	
Glass Type	Stage in Machine Cycle	Average Value of Log η (as quoted by Boow & Turner)	Corresponding Average Temp. °C.	New Value of Log η	Temperature Needed to Restore °C.	New Value of Log η	Temperature Needed to Restore °C.	New Value of Log η	Temperature Needed to Restore °C.
I	Gob formation	3.67	1018	3.59	1008	3.52	999	3.42	983
	Leaving parison mold (Interior	3.84	995	3.77	986	3.70	978	3.58	961
	Leaving parison mold)Exterior	4.50	922	4.42	914	4.35	907	4.19	891
	Entry to blow mold (Interior	4.39	933	4.31	925	4.24	918	4.09	902
	Entry to blow mold)Exterior	5.20	859	5.12	852	5.03	845	4.87	832
II	Gob formation	3.67	1032	3.57	1019	3.52	1010	3.41	994
	Leaving parison mold (Interior	3.84	1008	3.74	994	3.68	986	3.57	969
	Leaving parison mold)Exterior	4.50	923	4.41	919	4.34	906	4.20	892
	Entry to blow mold (Interior	4.39	937	4.28	926	4.21	918	4.10	904
	Entry to blow mold)Exterior	5.20	854	5.11	846	5.04	840	4.89	827
III	Gob formation	3.67	1070	3.60	1060	3.54	1052	3.38	1026
	Leaving parison mold (Interior	3.84	1045	3.77	1035	3.72	1028	3.54	1003
	Leaving parison mold)Exterior	4.50	964	4.43	956	4.36	948	4.16	927
	Entry to blow mold (Interior	4.39	977	4.32	968	4.25	961	4.06	938
	Entry to blow mold)Exterior	5.20	893	5.12	885	5.05	879	4.85	863
IV	Gob formation	3.67	1057	3.62	1050	3.56	1041	3.36	1013
	Leaving parison mold (Interior	3.84	1032	3.80	1025	3.74	1018	3.54	991
	Leaving parison mold)Exterior	4.50	948	4.44	941	4.40	936	4.21	918
	Entry to blow mold (Interior	4.39	961	4.34	954	4.28	948	4.09	928
	Entry to blow mold)Exterior	5.20	882	5.12	875	5.06	870	4.90	856
V	Gob formation	3.67	1060	3.62	1053	3.57	1046	3.46	1033
	Leaving parison mold (Interior	3.84	1036	3.80	1029	3.74	1023	3.65	1010
	Leaving parison mold)Exterior	4.50	953	4.46	948	4.40	943	4.32	935
	Entry to blow mold (Interior	4.39	965	4.36	960	4.30	935	4.22	945
	Entry to blow mold)Exterior	5.20	883	5.15	878	5.11	874	5.02	866
VI	Gob formation	3.67	1050	3.62	1043	3.58	1037	3.48	1021
	Leaving parison mold (Interior	3.84	1026	3.77	1018	3.74	1013	3.65	998
	Leaving parison mold)Exterior	4.50	942	4.44	936	4.39	931	4.27	916
	Entry to blow mold (Interior	4.39	954	4.34	947	4.29	942	4.17	928
	Entry to blow mold)Exterior	5.20	868	5.14	862	5.09	858	5.00	850



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SALES APPOINTMENT MADE BY AMERICAN POTASH

William F. O'Brien, Eastern States sales representative for American Potash & Chemical Corporation, has been appointed Manager of Lithium Sales for the company, it has been announced by William J. Murphy, Vice President in charge of Sales. Mr. O'Brien's appointment was made in line with the company's expansion program in the lithium field. He will headquarter in New York City.

Mr. O'Brien is a graduate of St. Peter's College, Jersey City, New Jersey, and was assistant to the president of Naco Fertilizer Company, a subsidiary of W. R. Grace & Company, before joining American Potash in 1952.

Active in the field of lithium expansion, American Potash & Chemical Corporation has recently announced plans to construct a $6,000,000 lithium chemicals manufacturing plant near San Antonio, Texas.

FIBER GLASS USED FOR SCREENING MATERIAL; THERMOPANE IN NEW SIZES

Libbey-Owens-Ford Glass Company has announced that its glass yarn is now being used in fiber glass screening. Called "Glasscrene," the screening material is manufactured by the Federal Screen Supply Company, Miami, Florida.

According to D. W. Lyon, Textile Sales Manager for the firm's Fiber Glass Division, the fiber glass screening is extremely strong, resistant to rust, stains and fire, does not shrink or sag and is unaffected by changes in the weather. Each strand in the new screening material is woven from minute glass filaments which, in spite of their light weight, have a strand tensile strength of 250,000 pounds per square inch.

Mr. Lyon further explained that the fiber glass yarn used in the screen is coated with a tough, weather-resistant vinyl, and when the yarn is woven into screening, the strands are fuse-loomed to keep them from unraveling. The screening weighs less than four pounds per 100 square feet and can be folded like cloth without creasing.

Libbey-Owens-Ford also reported that due to the increasing demand for bigger picture windows, they have added three, new large Thermopane insulating glass units to their list of standard sizes. The three new standard sizes, all of ¼-inch plate glass with a ½-inch air space hermetically sealed between the panes, are 93 x 48½, 93 x 60⅜ and 93 by 36 inches.

BROCKWAY APPOINTS EXECUTIVE VICE PRESIDENT

Brockway Glass Company has announced that, at the regular meeting of the Board of Directors, Finley B. Hess was elected Executive Vice President.

Mr. Hess has been associated with the company since 1932 and, until his recent promotion, filled the office of Vice President in charge of Operations.

Current Statistical Position of Glass

Employment and payrolls: Employment in the glass industry during October 1954 was as follows: *Flat Glass:* The preliminary figure was 27,100, which is 5.4 per cent higher than the adjusted 25,700 reported for September. *Glass and Glassware, Pressed and Blown:* An increase of .2 per cent is shown in the 75,900 employment figure for October when compared with September's 75,700. *Glass Products Made of Purchased Glass:* The preliminary 14,300 reported is 2.8 per cent higher than the adjusted 13,900 for September.

Payrolls in the glass industry during October 1954 were as follows: *Flat Glass:* Preliminary payrolls of $12,085,064 indicated a rise of 8 per cent when compared with the adjusted $11,185,668 for September. *Glass and Glassware, Pressed and Blown:* An increase of 1.2 per cent is shown in September payrolls of $23,753,158 over the previous month's adjusted $23,464,224. *Glass Products Made of Purchased Glass:* October preliminary payrolls were $3,957,811, or 5.1 per cent above the previous month's adjusted $3,762,776.

GLASS CONTAINER SHIPMENTS
(All Figures in Gross)

Narrow Neck Containers	November, 1954
Foods	829,000
Medicinal & Health Supplies	1,134,000
Chemicals, Household & Industrial	808,000
Beverages, Returnable	257,000
Beverages, Non-returnable	53,000
Beer, Returnable	65,000
Beer, Non-returnable	496,000
Liquors	927,000
Wines	377,000
Toiletries & Cosmetics	617,000
Sub-total (Narrow)	5,563,000
Wide Mouth Containers	
Foods	*2,535,000
Dairy Products	245,000
Medicinal & Health Supplies	367,000
Chemicals, Household & Industrial	136,000
Toiletries & Cosmetics	183,000
Packers' Tumblers	135,000
Sub-total (Wide)	3,601,000
Total Domestic	9,164,000
Export Shipments	287,000
TOTAL SHIPMENTS	9,451,000

* This figure includes Fruit Jars and Jelly Glasses.

GLASS CONTAINER PRODUCTION AND INVENTORY
(All Figures in Gross)

		Production November 1954	Stocks November 1954
Foods; Medicinal & Health Supplies; Chemicals, Household & Industrial; Toiletries and Cosmetics	Narrow Neck	3,367,000	4,418,000
	Wide Mouth	*3,295,000	*4,255,000
Dairy Products		264,000	314,000
Beverages, Returnable		263,000	1,316,000
Beverages, Non-returnable		41,000	188,000
Beer, Returnable		98,000	420,000
Beer, Non-returnable		423,000	717,000
Liquors		957,000	1,097,000
Wines		420,000	495,000
Packers' Tumblers		124,000	203,000
TOTAL		9,252,000	13,423,000

* This figure includes Fruit Jars and Jelly Glasses.

Glass container production, based on figures released by the Bureau of Census, was 9,252,000 gross during November 1954. This is 14.6 per cent below the 10,843,000 gross produced during October and 3.8 per cent below November 1953's 9,621,000 gross. Total glass container production during the January-November 1954 period has reached 116,166,616 gross. This is 1.7 per cent above the 114,131,933 gross produced during the same 1953 period.

Shipments of glass containers during November 1954 were 9,451,000 gross. This is a drop of 8.7 per cent from October shipments, 10,354,000 gross, and is 3.2 per cent higher than November 1953 shipments, 9,150,000 gross. Total shipments at the end of the 11-month 1954 period are 113,056,195 gross, which is 1 per cent higher than the corresponding 1953 period when shipments were 111,835,110 gross.

Stocks on hand at the end of November 1954 were 13,423,000 gross, which is 1.9 per cent less than the 13,684,000 gross on hand at the end of October and 17.8 per cent higher than the 11,388,000 gross on hand at the end of November 1953.

Automatic tumbler production rose 12.8 per cent during October 1954 to record a figure of 5,780,393 dozens. September production was 5,122,419 dozens, and October 1953 production was 5,449,722 dozens. Shipments during October were 6,270,215 dozens, which is a jump of 31.5 per cent over the previous month's 4,768,140 dozens. Shipments during October 1953 were 5,716,071 dozens. Stocks on hand at the end of October 1954 were 8,534,861 dozens, which is 5.5 per cent below the 9,036,474 dozens on hand at the end of September.

Table, kitchen and household glassware: Manufacturers' sales of machine-made table, kitchen and household glassware during October 1954 were 4,175,224 dozens. This is 19.1 per cent above the 3,503,309 dozens sold during September. Sales during October 1953 were 3,725,206 dozens. Total sales during the 12-month period ending October 1954 were 37,345,171 dozens, or 9.5 per cent less than the 41,268,000 dozens sold during the same period in 1953.

FOOTE LOWERS PRICE OF LITHIUM HYDROXIDE

Foote Mineral Company has announced a substantial reduction in the price of lithium hydroxide monohydrate.

Reductions, covering all price brackets, average 15% and reflect the economies of expanded production at Foote's Sunbright, Va., and Kings Mountain, N. C., plants. This action confirms the established Foote policy of encouraging greater usage of lithium in industry.

DR. H. E. SIMPSON RECEIVES ENGINEERING LICENSE

Dr. Harold E. Simpson has just recently received a Professional Engineering License to practice in the State of New York. This license and registration certificate was granted by the Education Department and the State Board of Examiners at Albany, New York, and was based on past professional engineering experience.

Professor of Glass Technology at the New York State College of Ceramics at Alfred University, Dr. Simpson graduated from Ohio State University in 1925, receiving his B. Cer. Eng. He received his M.S. degree in 1926 and his Ph.D. degree in 1929 from Ohio State. From 1929 to 1931, he was Professor of Ceramic Engineering at Rutgers University, where he organized courses in glass technology and vitreous enamels. In 1936, Dr. Simpson received the degree of Professional Engineering at Ohio State University. The same year, he joined Mellon Institute as an Industrial Fellow for the Pittsburgh Plate Glass Company where he carried out work related to dissolved gases in glass, as well as durability problems.

In 1944, Dr. Simpson was Industrial Fellow for Mississippi Glass Company at Mellon where he worked with Dr. J. C. Hostetter, then President of the glass company. In 1949, he was made a Fellow of the American Ceramic Society, of which he has been a member since 1924.

DR. I. C. GARDNER RECEIVES IVES MEDAL

Dr. Irvine C. Gardner, Chief of the Optics and Metrology Division of the National Bureau of Standards, has been awarded the 1954 Frederick Ives Medal for Distinguished Work in Optics by the Optical Society of America. Presentation was made at the Society's meeting in Los Angeles.

The Frederick Ives Medal was first awarded in 1929 and Dr. Gardner is the fifteenth distinguished scientist to receive the honor. In the citation for the award, the Ives Medal Committee commended Dr. Gardner for making many personal scientific contributions during the same period that he directed the program of the National Bureau of Standards in the field of applied and geometric optics.

Dr. Gardner's personal work has covered photogrammetry, photographic objectives, design and construction of optical instruments, military optical devices and the testing of optical instruments.

• John B. Fullen, an official of Kopp Glass, Inc., has been appointed Program Chairman of the Glass and Ceramics Section of the National Safety Council for the 1954-1955 term. Mr. Fullen, who is in charge of his company's plant maintenance, safety, traffic and packing department, has been active in the National Safety Council since 1950.

CORNING NAMES DR. W. H. ARMISTEAD AS RESEARCH AND DEVELOPMENT HEAD

Corning Glass Works has announced the appointment of Dr. William H. Armistead as Director of Research and Development. Dr. Armistead fills the position recently vacated by Dr. Edward U. Condon, who resigned to go to California where he will engage in fundamental scientific research. Named to the position of Associate Director of Research is Dr. Harry R. Kiehl, former assistant to the Director of Research and Manager of the Physics Department.

Dr. Armistead's entire research career has been spent at Corning Glass Works since he obtained his doctorate in chemistry at Vanderbilt University in 1941. He received his bachelor's degree in chemical engineering at Vanderbilt in 1937 and his master's in 1938. Three years later, he joined Corning as a research chemist and in 1950 became a senior research associate. In 1954, he was named Manager of the Melting Department of the Research and Development Division.

The new research director has made numerous inventions, primarily in the field of glass compositions. He is the fifth man to direct Corning's research laboratory since its establishment nearly a half-century ago under the direction of Dr. Eugene C. Sullivan.

Dr. Kiehl has been associated with Corning since 1934. He obtained both his master's and doctorate in physics at Pennsylvania State University, having been graduated from Lebanon Valley College in 1925. In 1948, he was assigned to television bulb development, and in 1950 was appointed Manager of Pilot Plant No. 2. He has been assistant to the Director of Research since 1951.

AMERICAN POTASH ELECTS DIRECTOR

Robert B. Coons, Vice President of American Potash & Chemical Corporation, has been named a Director of the company, according to an announcement by Peter Colefax, President. The appointment increases the size of the company's Board of Directors from eight to nine.

Mr. Coons, who is in charge of Industrial Relations, Purchasing and Traffic, joined American Potash & Chemical Corporation in 1946 as assistant to Mr. Colefax, and was named a Vice President in 1947. He is also a Director of the Plomb Tool Company and of the Los Angeles Merchants and Manufacturers Association.

THE COVER

Typical of the special testing instruments at the research center of The Pfaudler Company, manufacturers of glassed-steel and alloy equipment, is this machine for testing the thermal shock resistant properties of glassed-steel.

Arthur Rood, laboratory technician, watches as sample glassed-steel cylinders, heated to high temperatures, are quenched in water at approximately 55°F. The samples are then statifluxed, or dusted, with a white chalk and examined for possible cracks and fractures. These tests are conducted on all new glass formulations and also for spot checks on regular production formulations.

HIGH OPACITY EXTENDS COVERAGE OF DRAKENFELD SPRAY COLORS

It is no secret why every pound of Drakenfeld Spray Color goes much further than you'd ordinarily expect. We know from long experience how to provide tops in opacity without sacrifice of gloss, and at minimum firing temperatures. Lead release is extremely low: Drakenfeld Spray Colors are carefully compounded to resist food acids and sulphides; retain their high gloss and color strength.

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All Drakenfeld Spray Colors are shipped in reuseable 5-gallon steel pails with quick-acting rim lock for easy cover removal and replacement. Settling while standing and in transit is minimized by special processing methods. Get full details about these money-saving spray colors. Write today.

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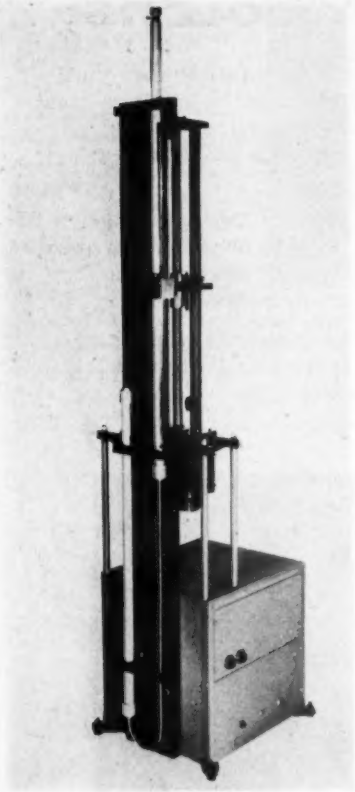

MANOMETER FOLLOWER

Fanger Research Laboratory, 15891 Santa Clara-Los Gatos Road, Los Gatos, California, has announced the manufacture of its Exactel Manometer Follower, which combines accuracies up to 0.001% of full scale with the sturdy reliability required in varied industrial applications.

The manometer follower is a custom built instrument, assembled mostly from standard parts to customer specifications. Normally the output information is presented as a proportional shaft position of a lead screw that positions the transducer. A high torque synchro generator is provided for electrically transmitting this shaft position to the readout or controlled equipment. Temperature control is usually desirable and is provided by enclosing the instrument, except for electronic components, in an insulated cabinet with thermostatic control. A precision Mercury in glass thermostat is used with an electric heater. The air within the cabinet is circulated by sealed ball bearing fans at the top and bottom. Access to the cabinet is not required for operation of the instrument, thereby providing a good means for making the instrument dust and tamper proof.

VARIABLE RATIO GAS REGULATOR

The North American Mfg. Company, 4455 East 71st Street, Cleveland 5, Ohio, has introduced its Series 16 variable ratio gas regulator for use with burners that operate well on lean air-gas ratios at low firing rates, such as the Series 123 and Series 223G XSA gas burners.

The Series 16 features a special adjustment that permits a negative setting as high as 6 osi. By setting the regulator negative, cross-connecting to the main air line and adjusting the limiting orifice gas valve for correct air-gas ratio on high fire, an arrangement is established which gives a progressively leaner air-gas ratio as the main air is turned down. This automatic use of excess air at lower firing rates maintains the temperature uniformity which is frequently lost in a furnace when the burners are operated at less than maximum firing rates.

RECORDER-CONTROLLER

Robertshaw-Fulton Controls Company, Fielden Instrument Division, 2920 North Fourth Street, Philadelphia 33, Pa., has announced a self-balance recorder-controller called the Series 42 Radio Frequency Capacitance Bridge.

The new instrument was designed primarily for the measurement and control of levels of liquids, granular solids, interface and other conducting and nonconducting substances. It is also used for other process variables, such as moisture content or composition. Electrical and pneumatic control forms can be incorporated within the single housing of the Series 42, according to the announcement.

CATALOGS RECEIVED

Applied Physics Corporation, Pasadena, California, has announced the availability of a new 16-page catalog which gives a detailed description of performance, construction, specifications, accessories and modifications on their Model 11 and Model 14 Cary recording spectrophotometers. The Model 11 is for ultraviolet and visible spectra recording and Model 14 covers ultraviolet, visible and infrared regions.

Also included is a brief description of features of other Cary instruments: Raman spectrograph, electrometers, infrared analyzers and ultraviolet analyzers.

J. H. France Refractories Company, Snow Shoe, Pa., has issued two new single sheet bulletins on the company's complete line of refractory castables.

The bulletins contain brief product descriptions, as well as recommended applications for FranReCo refractory castables sold under the trade name Hydrecon 3000, 5, 186 and 186 Extra Strength.

A special table is devoted to composite, detailed technical and ordering information on each specific castable product, with particular reference to recommended use limits, modulus of rupture, linear change and cold crushing strength.

The Bristol Company, Waterbury 20, Conn., has just published a new bulletin on its complete line of millivoltmeter pyrometers and accessories.

Included in its Bulletin P1244 are the new Model 580 indicating pyrometers for service up to 4000° F., indicating controllers with mercury switches or Thryatron-operated relays and portable indicating pyrometers. Also included are two-point and multiple-point pyrometer switches for use when a single indicator is intended to monitor temperature measurements from more than one station.

Corning Glass Works, Corning, New York, has published a new edition of the manual, "Laboratory Glass Blowing with Pyrex Brand Glasses," a 20-page booklet offering laboratory personnel information about the working characteristics of Pyrex brand and Vycor brand glasses.

Fundamental glass blowing operations and recommendation for suitable tools and equipment are included. Additions in the revised issue include new drawings, new methods of identifying and marking Pyrex brand glass No. 7740, an enlarged section on lampworking Vycor brand 96 per cent silica glass No. 7900, a description of special apparatus and specifications of Pyrex brand glass tubing rod.

Fisher Scientific Company, 717 Forbes Street, Pittsburgh 19, Pa., has issued an 8-page, well illustrated bulletin, FS-246, explaining the theory and use of a new additive-colorimeter desited to serve as a permanent "color memory" for control chemists.

Patterson-Kelley Company, Inc., East Stroudsburg, Pa., has issued a new catalog on blending, processing and heat exchange equipment for the chemical and processing industries.

Bulletin 13 provides photos and specifications on a variety of sizes and adaptations to the company's three basic types of blenders. Production sizes are available on the ribbon, double cone and patented twin shell models, and one pint to 8 quart laboratory sizes for the twin shell. Twenty different cooling and heat exchange units are shown, with many devoted to specialized applications.

109,423 tons of flint glass *without feathering*

"You can be proud of this performance", says glass plant general manager

Furnace: Cross-fired; regenerative
Type of glass: Soda lime flint
Area of melting end: 700 sq. ft.
Total operating days: 1,038
Total tons melted: 109,423
Average tons per operating day: 105.4
Tons per sq. ft. of melting end for entire campaign: 156.3
Average rate of pull, sq. ft./ton: 6.64
Maximum rate of pull, sq. ft./ton: 5.70
Minimum rate of pull, sq. ft./ton: 8.50
Furnace depth: 42 inches
Fuel used: Natural gas

That's the kind of service you expect with Laclede-Christy 12-inch CAST 400 Bottom Blocks

The campaign that produced 109,423 tons of soda lime flint glass covered 35 months and 3 days. It happened in northern California. And, it's only one of similar records reported throughout the country.

Laclede-Christy 12-inch Cast 400 bottom blocks used measured 4¼ in. to 8¼ in. thick *at the joints*—after 1038 operating days. No glass feathering occurred through the bottom joints.

This data tends to prove one point: You certainly get your money's worth *and more* when you use Laclede-Christy Refractories. The "quality-first" symbol proves itself on the job—as it will for years and years to come. Why use any refractories other than Laclede-Christy?

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A. J. Martin, Director Industrial Relations of Owens-Illinois Glass Company, addresses Overmyer group.

OVERMYER SERVICE AWARDS

Overmyer Mould Company's Eighth Annual Service Awards Banquet was successfully concluded November 22, 1954 at the Beeson Club House. A fast-moving informal type of program assured an enjoyable evening for the employees receiving awards.

Immediately following dinner, E. R. Flatter, Vice President of the company, introduced the guests of honor, Floyd Warren, Mayor of Winchester, Robert Miles, President of the Foundry Workers Local No. 24, James Gartley, President of the A.F.G.W.U. Local No. 112, Dale Rouch, President of the A.F.G.W.U. Local No. 518, Robert Isenbarger, President of the Pattern Makers Local, James Kindelan, Branch Manager of Overmyer Mould Company of Pennsylvania, and Day Stalker, Branch Manager of Overmyer Mould Company of California. Other out-of-town guests were James Brakeman, President of Lubracrome Corporation, and Ed Langas, Personnel Director of Owens-Illinois Glass Company.

Award presentations were made by company officials beginning with the ten-year group. Charles Manrose, Secretary-Treasurer, presented dark blue lapel pins inscribed with Omco and the numeral 10 to the following: Charles Alexander, Charles Blizzard, Robert Blizzard, Kenneth Clark, Charles P. Edwards, Dorothy Edwards, Howard Edwards, Marvin Everhart, Clarence Fast, Beneville Kelly, Helen Kidwell, Carlton Lesley, William Long, Charles Morford, Merle Moyer, Leon Overmyer, John Peperak, Earl Pflasterer, Ralph Polley, Stanley Roskosz, Wayne Rouch and Oscar Roy.

Max Hawkins, Sales Manager, made the presentations to the 15-year group, who received pins inscribed with the numeral 15 on a maroon background. The awards group was as follows: Raymond Barnhart, Esther Bragg, John Brawley, Gail Carter, Newton Davis, Ralph Davis, Raymond Davis, Chris Flatter, Clarence Frazier, Byron Lumpkin, Lou Mendenhall, Walter Mills, John Moore, Carl Pettyjohn, Archie Spencer, Bernard Wagner and Bessie Williamson.

Vernon Ruble, Mould Division Superintendent, presented lapel pins with the numeral 20 inscribed on a background of light blue to the 20-year awards group: Guy Bailey, Russell Cole, Roger Conner, Donald Dixon, Frank Edwards, Gerald Fisher, Norval Gaylor, Joseph Green, Oyvin Gustin, Luther Haisley, Edward Hart, Ephriam Horr, William MacKendrick, Roy Reich and George Wood.

Wilbur Snyder, Foundry Division Superintendent, presented lapel pins to the 30-year awards group. The pins were inscribed with the numeral 30 on a dark blue background with a small band of white in the center. The 30-year award recipients were as follows: Frank Bitzer, Edgar Conley, Raymond Conyers, Charles Cox, Max Hawkins, Harold Ryan, Arthur Sanzo and Joe Sanzo.

Special recognition was given to the members of the Omco 25-year club. Each person in this group has service ranging from 26 to 32 years. They are as follows: George Flanagan, 32, Carl Flatter, 32, Glen Gartley, 32, Donald Strahan, Sr., 32, John Elder, 31, Cecil Green, 29, Calmar Jones, 29, Marlin Jones, 29, Frank Maliff, 29, John McCoy, 29, Joseph Bishop, 28, Reginald Elliott, 28, John Harris, 28, M. D. Hutchings, 28, Lester Jarrett, 28, John Monks, 28, Cecil Monroe, 28, Donald Osborn, 28, Wilbur Snyder, 28, Day Stalker, 28, Ira Wolfe, 28, Harry Wood, 28, Kenneth Wood, 28, E. R. Flatter, 27, Kenneth Grow, 27, William Laricks, 27, Elmer Mack, 27, William P. Morris, 27, Edgar Payntor, 27, Donald Smith, 27, Lester Potter, 26, Arthur Smith, 26, Floyd Summers, 26, Lee Ward, 26.

The focal point of the evening were the engraved Hamilton wrist watch awards to the new members of the Omco 25-year club. The presentations were made by Lowell Roesner, President of the firm, to William Comer, Lyle Overmyer, Ray Fogle, Harry Willits and Ed Perry.

THREE NAMED TO ENGINEERING POSTS AT WESTINGHOUSE TUBE DIVISION

Richard T. Orth, Vice President of the Electronic Tube Division, Westinghouse Electric Corporation, has announced the promotion of Dr. Ernest A. Lederer to the newly-created position of Chief Engineer of the division. At the same time, it was announced that Carmen E. Ramich has been named Manager of Engineering, the post formerly held by Dr. Lederer, and that Dewey D. Knowles has been appointed Manager of Product Administration.

In his new position as Chief Engineer, Dr. Lederer will maintain liaison within the industry on technical matters and will assist Mr. Orth on matters relating to technical policy. In addition, his duties encompass complete responsibility for all advanced development of product engineering.

Dr. Lederer served in research and engineering capacities for the Westinghouse Lamp Division, then became chief engineer for the National Union Radio Corporation. He also served with R.C.A.

Mr. Ramich has been associated with Westinghouse since 1948, and Mr. Knowles joined the firm in 1923.

CORNING TO SPLIT COMMON STOCK

Pending stockholders' action, the Board of Directors of Corning Glass Works has approved a 2½-for-1 split of its common stock. The directors' plan for a stock split provided for a special meeting of company stockholders to be held January 22 in order to vote upon the proposal to split the common stock, both issued and unissued.

The plan would increase the number of authorized shares of common stock, $5 par value, from 3,000,000 shares to 7,500,000 shares and the number of outstanding shares from 2,659,008 shares to about 6,647,500 shares.

PROCESS DEVELOPMENT ASSIGNS J. GILBERT MOHR

Norman Nitschke, President of Process Development Company, Inc., has announced that J. Gilbert Mohr has joined the company as General Manager. Mr. Mohr was formerly Quality Control Manager of the Libbey-Owens-Ford Glass Company, Fiber Glass Division.

Prior to joining Process Development, Mr. Mohr was also engaged in glass research with Libbey-Owens-Ford, with Corning Glass Works and with E. I. du Pont de Nemours & Co., Inc. He attended Pennsylvania State College and Alfred University.

H. Robinson, formerly of Firestone Tire and Rubber Company's Research Division, has also recently joined the production department of Process Development Company. The firm is currently engaged in the manufacture of glass fiber products for air filters, paper strengthening and fiber glass reinforced plastics.

STAUFFER APPOINTMENT

Hans Stauffer, President of Stauffer Chemical Company, has announced the appointment of H. D. McGowan as Assistant Director of Market Development.

Mr. McGowan was formerly associated with the General Chemical Division, Allied Chemical & Dye Corporation, and was later the Vice President and General Manager of Algonquin Chemical Company.

• The Hauck Manufacturing Company has announced the appointment of Leonard J. Shorek as engineer and district representative for the Detroit territory.

CENTRAL GLASS & CERAMIC INSTITUTE PUBLISHES BULLETIN

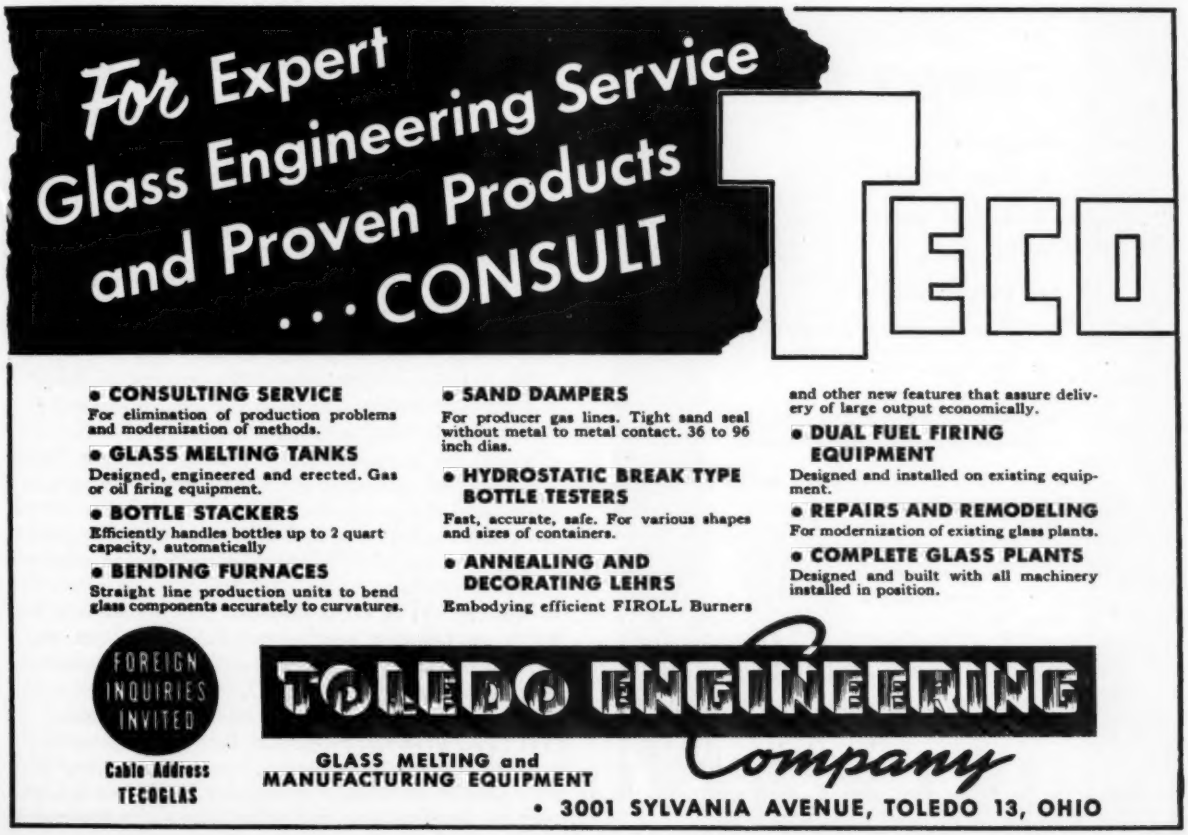
Announcement has been made of the publication of the Bulletin of the Central Glass & Ceramic Institute of Calcutta, India. To be published as a quarterly Bulletin, Volume I, Number 1, appeared in August 1954.

Features of the magazine include general discussions, a technical section, industrial articles, a quality control section, an inquiry and reply section, statistics, news and reviews, books section and abstracts. The technical section of the first volume discusses, e.g., containers suited for distilled water, the industrial experiences with natural sillimanite in the glasshouse. The statistical section summarizes imports 1950-54 and production 1946-53, showing particularly the growth of sheet glass manufacture.

O-I TO OPEN WASHINGTON OFFICE

Owens-Illinois Glass Company has announced plans to open a sales branch in Yakima, Washington. The announcement from K. C. White, Vice President and General Sales Manager of the company's Pacific Coast Division, named J. E. Humphrey, salesman in the Seattle branch and a veteran of 20 years service with Owens-Illinois, as Manager of the new branch.

Mr. White said that the population growth in the northwest, the increasing importance of the Yakima Valley apple and grape juice packing industry and an over-all greater demand for glass containers were the principal reasons for making the move. The new branch, to be located in the Larson Building, will serve eastern Washington, western Montana and northeast Oregon.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Efficiently handles bottles up to 2 quart capacity, automatically
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Straight line production units to bend glass components accurately to curvatures.
• SAND DAMPERS
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LITHIUM . . .

(*Continued from page* 22)

least poorly soluble in water. Acid resistance is improved through the use of lithia, principally by taking advantage of its fluxing effect to keep the total alkali content to a minimum. In glasses, the resistance of lithia to alkalies, while not good, is probably better than the corresponding glasses containing soda and potash. This improved resistance may be connected with the ability of the lithium ion to bond oxygen ions tightly even when serving only in a modifying position in the network.

The definite improvement in hardness of glasses and glazes through the use of lithia seems to be related to a "contracting" or "tightening" effect of the oxygen ion in the presence of the lithium ion. Fajans and Kreidl[22] demonstrated that a progressive tightening of the oxygen ion, as reflected in lower molar refractions of O^{-2}, is encountered in the series $2Ba^{+2}$, $2Sr^{+2}$, $4Na^{+}$, $2Ca^{+2}$, $4Li^{+}$, Al^{+3}–Na^{+}, Al^{+3}–Li^{+}, etc. This tightening indicates that the substitution, for example, of lithium for sodium in a silicate glass, results in lower molar refraction of oxygen.

While lithia is believed to extend the range of useful glasses, in many instances there is a pronounced tendency for simple lithium silicate glasses to devitrify. Stookey[23] in his patent related to photosensitive opacifiable glass has taken advantage of this characteristic devitrification to produce translucent linear portions for use as louvered windows. The following batch taken from the patent illustrates the type of lithium glass used:

Sand	1,000
Na_2CO_3	19
$NaNO_3$	17
Li_2CO_3	390
$BaCO_3$	160
$Al(OH)_3$	42
AgCl	1.1
Cerium Hydrate (75% CeO_2)	0.32
Na_2SiF_6	5.6

Lithia also appears to offer possibilities in reducing the high temperature viscosity of the glass which may provide lower melting temperatures and lower forming temperatures. It is also known to affect the quality and characteristic color of various metallic colorants. As a modifier of colors, its application may be broadly applied.

VI. Future Possibilities of Lithia in Glass

The future possibilities of lithia as a raw material in glass appear to be extremely promising, especially as more extensive and reliable sources of lithium chemicals and minerals are made available to the industry. Lithia appears to be applicable in a wide variety of glasses and offers versatile properties. The application may include flat glass, containers and hollowware, optical glass, as well as chemical-specialty ware, television tubes and other electronic products.

Industry will no doubt desire to take full advantage of its strong fluxing power, improved melting, better durability, increased hardness, lower thermal expansion and desirable electrical properties.

Its use as an opalizer and modifier or stabilizer of colors is not clearly understood, but these characteristics merely add to its long list of versatile properties. They offer unusual advantages and should be exploited. Lithia may also be of value in the field of glass fibers where melt-

ing, viscosity control and durability are known to be highly important.

Now that more reliable and cheaper sources of industrial lithium chemicals and minerals are available, the future of this material as applied to various branches of the glass industry will be watched with considerable interest. It is believed that glass will be enhanced and improved by its intelligent application.

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A.C.S. SECTION ACTIVITIES

At the December meeting of the Upper New York State Section of the American Ceramic Society, speaker for the evening was Gordon P. K. Chu, Research Engineer of The Pfaudler Company. Mr. Chu's topic was "Some Observations of Water and Gases in Glasses and Enamels."

The Pittsburgh Section of the Society held its Annual President's Night meeting on January 11. Guest of honor and speaker was Ray W. Pafford, President of the A.C.S. Mr. Pafford is Vice President and General Manager in charge of Production for the Acme Brick Company. His subject was "Some Observations of the Southern and Western Brick Industry." He has recently completed extensive travel through the Southern and Pacific Coast Areas and has collected considerable data that are applicable to the brick industry.

The Northern Ohio Section, at its December meeting, featured Dr. G. H. McIntyre, Vice President and Technical Director of Ferro Corporation, who gave a talk on "New Developments in Ceramics." He discussed an entirely new material, hollow ceramic spheres, as well as recent ceramic developments for architecture, agriculture and foundry practice. The evening topic was "Business Outlook for 1955" presented by Fred Kiel, Senior Economist of the Federal Reserve Bank of Cleveland.

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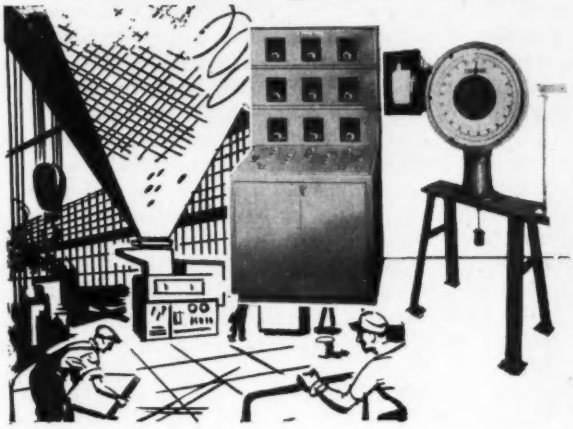

APPLICATION

The Thurma-Tronic batching system is adaptable for use in any batching operation of the glass industry. This new electronic batching system is not only available for new plants but it is also adaptable to most existing plants. If you wish to increase production and reduce batching costs, it will pay to investigate the money-saving advantages of the automatic and accurate Thurma-tronic batching system.

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FOR ALL BATCHING PLANTS . . . OLD or NEW—The Thurma-tronic batching system may be used on any existing plant as well as on original installations.

UNLIMITED INGREDIENTS and FORMULAS—Because of the electronic design, any number of materials may be controlled. In addition, any number of preset formulas may be weighed by the Thurma-tronic batching system. Changes in formulas are quickly made by resetting the dials.

RAPID WEIGHING—The Thurma-tronic batching cycle is accomplished in a matter of seconds. This system may be set by the operator for one batch, continuous batching or any specific number of batches.

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ACCESSORIES—Strip chart recorders, one turn dials and other modifications are available for specific requirements of any batching operation.

Complete information on Thurma-tronic batching systems is available by writing for Bulletin 701. If, however, you have a specific batching problem, give us general information and our engineers will be glad to work out the details with you.

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(*Continued from page* 31)

ously, current regulators tend to regulate temperature because of the negative temperature coefficient of the glass. Direct temperature regulators are somewhat difficult to apply for two reasons: (1) it is hard to measure accurately the temperature of molten glass due to its translucency. This permits radiation from the tank structure to impinge on the measuring device; and (2) thermocouple measurements may be disrupted by the electrical fields within the molten glass. For these reasons current regulators have been used more commonly than direct temperature regulators in electrical glass melting.

The saturable reactor system lends itself nicely to use with an electronic current regulator, a device which is fundamentally quite simple. It receives an indication of current flowing into the furnace electrodes and converts this into a d-c voltage. This voltage is compared to a reference voltage in the regulator and the error voltage (difference between these two) is amplified and used to control the output of the regulator. The output is a d-c voltage which is used to supply current to the excitation winding of the saturable reactor. Circuits are provided to prevent hunting of the regulator and to provide adjustments of the desired current and regulator sensitivity. Conventional relays and control systems are used in automatic regulators for the induction regulator systems.

As mentioned before, there are five factors which should be considered when selecting a basic system: (1) first cost; (2) maintenance; (3) operation; (4) efficiency; and (5) power factor. Similar systems as shown in Fig. 5 are used for a comparison of these five factors. Although there are many different ideas regarding furnace transformer taps and connections, required power factor, etc., all of these variations cannot be considered. The two basic systems shown are satisfactory for this comparison.

The selling prices for the two basic systems are compared in Fig. 10. These prices include the induction regulator or saturable reactor, the furnace transformer and an automatic current regulator. The curve is drawn through the points representing standard ratings. Thus the curves would have to be adjusted upward for non-standard or in-between sizes. The saturable reactor is lower in first cost, but this is somewhat offset by some of the other factors to be discussed. The selection of the transformer connections and taps also have quite an effect on the selling price.

Maintenance of either of these systems is not a major consideration. The saturable reactor, an air-cooled static device, requires no maintenance except an occasional cleaning with an air hose. The electronic current regulator requires occasional tube replacements. However, all but two power tubes are similar to the type used in a home radio and may be purchased in any radio repair shop at a cost of one or two dollars apiece. The two power tubes cost a maximum of about 40 dollars each for the large size regulator. The induction regulator and its associated control require only the normal amount of maintenance given to conventional control and switchgear type apparatus. Thus the maintenance for either of these systems is quite low and can be considered similar.

The operation of these systems is quite simple. For the saturable reactor system, a single knob is used to adjust

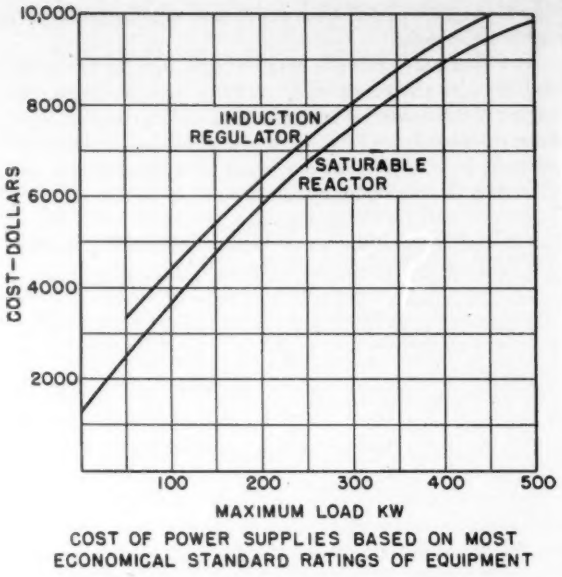

Fig. 10. First costs for the two basic systems.

for the desired current. In addition to this, a series-parallel switch must be operated when it is desired to go from one voltage range to another. For control of the induction regulator system, there is also a current adjusting knob and a series-parallel switch. Thus the operation of either of these systems from the viewpoint of the operator is basically the same. The equipment may look a little different but the operations are essentially identical.

The power factor of the saturable reactor control is strictly proportional to voltage. At the maximum voltage obtainable with any transformer connection, the power factor is something over 90 per cent at full load. Below this maximum voltage, the power factor is reduced and equals the voltage when this voltage is expressed as a percentage of the no-load voltage.

The power factor of the induction regulator control system is almost constant and for all practical purposes equal to 100 per cent. The transformer action of these devices does not cause a shift in power factor regardless of the voltage or load.

If the furnace load is a large part of the total plant load, power factor penalty clauses may be encountered with the saturable reactor system. This can be corrected by a permanent bank of capacitors which will lessen the shift in power factor, or additional furnace transformer switching and tap changing may be used. This switching and tap changing has the effect of reducing the range over which the saturable reactor must work with the result that the power factor is improved for most conditions. If further power factor improvement is still required, a bank of automatically switched capacitors may be substituted. However, automatic switching of capacitor banks cannot usually be justified for this size load.

The over-all efficiencies for the two systems are both high and little different. Due to the excitation losses in the saturable reactor, its efficiency is somewhat lower. The induction regulator system efficiency at full load is between 97 and 98 per cent. The saturable reactor system efficiency is about one per cent less than this except for the very small sizes which are relatively inefficient. In

both systems the efficiency drops off with decreasing voltage particularly if full load current is drawn.

Thus, it appears that the major factors in determining which system should be used are the initial investment, power factor and the user's emotions regarding electronics. The figures given are not final since they do not include any equipment for power factor correction or may not suit the specific conditions precisely. However, the data furnished will provide some sort of guide in the preliminary selection of equipment to be used for electric glass melting applications.

CARBORUNDUM REFRACTORIES DIVISION STAFF CHANGES

Clarence E. Hawke, Vice President of The Carborundum Company and General Manager of its Refractories Division in Perth Amboy, New Jersey, has retired from active direction of the Division, and Boyd M. Johnson, formerly Assistant General Manager, has been appointed General Manager, it has been announced.

Mr. Hawke, as a Vice President of the company and special consultant to the President, will give particular attention to the development and marketing of one of the company's newest products, "Fiberfrax" ceramic fiber, which is an extremely light refractory material adapted to high temperature applications.

Mr. Johnson joined Carborundum in 1920 shortly after receiving his B.S. degree in Mechanical Engineering from the University of Pittsburgh. He has served as product design engineer, Chief of the Engineering Department, Manager of Engineering, Sales Manager, Works Manager, Assistant Manager and Acting Works Manager. He was promoted to Assistant General Manager in 1952.

MINNEAPOLIS-HONEYWELL PURCHASES INSTRUMENT FIRM

Minneapolis-Honeywell Regulator Company has purchased all of the outstanding capital stock of Doelcam Corporation of Boston, Mass., manufacturer of precision instrument and control equipment for aircraft and industry uses, it has been announced by Paul B. Wishart, President of Minneapolis-Honeywell.

Mr. Wishart said that the New England firm, which has a main plant and administrative offices in Boston and another plant and engineering laboratories in Newton, Mass., would be operated as a new division of the company. There will be no change in the management, headed by John J. Wilson, President and founder of Doelcam.

SUPERINTENDENT OF O-I LIBBEY PLANT RETIRES

Earl W. Beck, veteran glass manufacturer who has been Superintendent at the Libbey Glass Division plant of Owens-Illinois Glass Company in Buffalo since 1948, has announced his retirement.

Mr. Beck, the original founder of Sharpe, Inc., Buffalo glass cutters, has an excellent knowledge of all phases of glass manufacture. He started in the glass business as a cutter for the T. B. Clark Company and served as a foreman at the Niagara Cut Glass Company before going with the Sharpe operation. He was with Sharpe for 37 years as Vice President in charge of Manufacturing.

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GLASS CONFERENCE . . .
(*Continued from page* 28)

the eye contains 130 million photocells. The act of seeing and perceiving are thus highly involved and most complicated. One individual was able to read 200 words per minute with 48% perception but, with training, exercises and work, he was able to read over 900 words per minute with 96% comprehension.

By the use of slides Dr. Renshaw showed that complicated patterns viewed for a time on the screen were seen to shift to different relationships. This relationship is known, for instance, to affect the color effects or the impressions one gets from such products as glass fibers. Not only color, but size, shape and form are all affected by their immediate environment and surroundings. Change of position of the object is not only important but change of position of the observer as well.

The genius of lightening calculation was revealed, and the process of the unusual ability to recognize and perceive with almost instantaneous speed was demonstrated. To read rapidly, one should be able to read five digits in $\frac{1}{10}$ sec. When one learns to read in groups by structure and pattern and related form, the comprehension of nine digits becomes just as easy as five. The increase in the rate of reading is the result of increased comprehension.

Many interesting and almost fantastic results were cited in the training of children as well as adults, all of which increased their ability to comprehend and understand at an increasingly rapid rate.

This talk was most interesting and entertaining, as well as informative. A mastery of the simple art of reading and understanding gives one a greater sense of mastery and confidence in his ability to accomplish greater work. Everyone left the meeting wishing that he could take advantage of such training. These methods certainly offer unusual advantages of education for future generations.

F. H. RIDDLE RECIPIENT OF 1955 BLEININGER AWARD

Frank H. Riddle, Vice President of Champion Spark Plug Company, has been named the 1955 recipient of the Albert Victor Bleininger Award. The medal and scroll representing the award will be presented to Mr. Riddle at the Bleininger Award Dinner to be held next March at the Hotel Schenley, Pittsburgh.

Mr. Riddle received his professional degree of ceramic engineering in 1931 from Ohio State University. In 1916, he became associated with Albert Victor Bleininger, serving as his assistant as head of the Clay Products Division of the National Bureau of Standards. In 1919, he became Director of Research for the Jeffery-Dewitt Company, which later changed its name to the Champion Spark Plug Company. In 1943, he was made Factory Manager of the Ceramic Division and in January 1945, became Vice President of the company.

• Announcement has been made of a Packaging Exhibition to be held at Olympia, London, January 18 through 28, 1955. It is expected that this will be the largest and most comprehensive exhibition of packaging yet staged in Britain.

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LACLEDE-CHRISTY PETROGRAPHIC SERVICE

A complete, up-to-date petrographic service section of the identification of glass stones has just been completed by the Laclede-Christy Company, Division of H. K. Porter Company, Inc., according to an announcement by W. L. Fabianic, Vice President in charge of Research.

Equipment for the new petrographic addition includes two microscopes, accurate index oils, photomicrographic set-up and all necessary equipment, plus an excellent stone library. The new facilities will be used to further research work in development of new products and as an aid to Laclede-Christy customers.

SALES EXECUTIVE ACHESON NAMES

A. T. Olsson has been named an Assistant Sales Manager of Acheson Colloids Company, according to Alden Crankshaw, General Sales Manager.

Mr. Olsson, formerly Service Engineer with offices in Detroit, has recently served in Acheson's main offices in Port Huron. His efforts will now be directed principally toward supervision of the company's service engineers in the field. This newly-created post will enable G. C. Giles, veteran Assistant Sales Manager, to take on added administrative responsibilities.

• Owens-Illinois Glass Company received a bronze award for the company's 1953 Annual Report, rated best in its industry by *Financial World*, sponsors of the annual competition.

EISLER ENGINEERING MAKES OFFICER CHANGE

Eisler Engineering has announced two important appointments, coinciding with the company's 35th anniversary. On January 1, Charles Eisler, Jr. became President, stepping up from the vice presidency, and Dr. Charles Eisler, founder of the firm in 1920 and its President until now, moved up to Chairman of the Board.

Mr. Eisler, Jr. holds mechanical, electrical and metallurgical engineering degrees from M.I.T. and Stevens Institute of Technology.

CORNING APPOINTMENT

E. K. Sutherland, senior field engineer in the Mechanical Engineering Department, has been appointed Manager of the newly-created Automation Engineering Department at Corning Glass Works, it has been announced by A. W. Weber, Director of Engineering.

Mr. Sutherland has been associated with Corning since 1945 when he joined the Mechanical Engineering Department as a research technician. He later was appointed an engineer in machine design and in 1951 was named a senior field engineer specializing in television bulb machinery.

• George W. Tall, Jr., Vice President and Secretary of Leeds & Northrup Company, was elected a Director of the National Association of Manufacturers at its recent Annual Meeting. Mr. Tall represented the Scientific Apparatus Makers Association and the Manufacturing Trade Group of the National Industrial Council.

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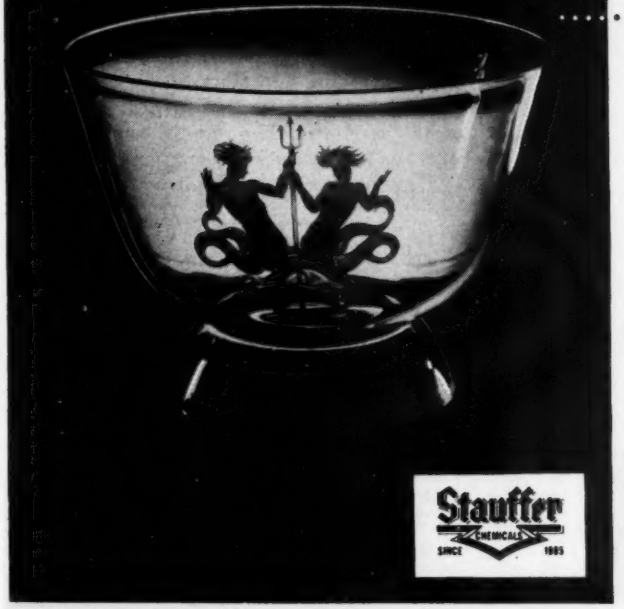

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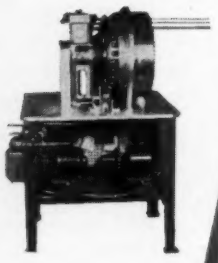

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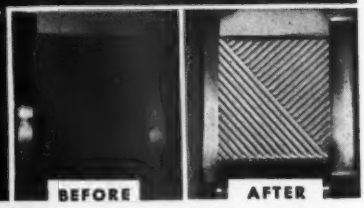

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INVENTIONS AND INVENTORS . . .

(*Continued from page* 34)

The invention relates to apparatus for coating the inner surface of hollow glassware for illuminating and irradiating purposes. This application is a division of Patent Number 2,586,348.

All operations of the coating process occur at the work station shown and are initiated, after the lamp bulb 5 is located at the station, by the upward movement of the holder 2 and the burner 1. These movements are brought about by the rotation of the drive shaft 6 and the cams 9 and 10, the former of which raises the holder 2 until it engages the inner surface of the bulb neck 7 and, through the engagement, lifts the bulb 5 from the rests 8 of the conveyor 4, and the latter of which raises the burner 1 into the bulb 5 through its neck 7. At the time the burner 1 and shield 22 are introduced into the neck 7 of the bulb 5, the upper end portion of the burner is located just above the top of the tubular metal shield 22 which is in effect the upper end of the holder 2, and a flame burns about a discharge opening completely around the end portion. The flame results from the combustion of gaseous ethyl silicate discharged laterally from between the metal shield or cap 23. Control over the amount of the combustible ethyl silicate gas discharged by the burner 1 is afforded through the control of the liquid ethyl silicate introduced into the burner 1, which liquid is drained by the force of gravity from a constant level reservoir 29 through the valve 30 and the flexible hose 31.

The patent contains 1 claim and 11 references were cited.

RESEARCH DIGEST . . .

(*Continued from page* 36)

carried out at a progressively lower temperature; and as the viscosity-temperature curves for each series of glasses with progressively increasing amounts of B_2O_3 are nearly parallel over the range 800°-1400°, the adjustment of operating conditions should be easy to make. Typical data is given in Table III.

(9) The softening point measured by the Littleton method is progressively lowered within each of the seven series of glasses by the progressive introduction of B_2O_3.

(10) In and near the annealing temperature range, introduction of boric oxide progressively increases the viscosity of all the glasses. The reversal temperature at which the effect on the viscosity becomes zero lies between 602° and 625°, varying with the glass.

CORNING APPOINTMENT

John A. Ross, a product engineer in the New Products Division of Corning Glass Works, has been appointed Manager of Quality and Product Engineering for the company's Consumer Products Division, according to John Carter, Vice President and Division Manager. Mr. Ross succeeds Harvey J. White, who has left the company.

A graduate of Lehigh University, Mr. Ross joined Corning in 1943 as a research assistant in the Research and Development Division. From 1944 to 1946, he served with the U.S. Navy, and then returned to Corning. For a brief period in 1946, he was assigned to the company's Bradford, Pa., plant, and in 1952 was named a product engineer in the New Products Division.

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LACLEDE-CHRISTY APPOINTS CHIEF INDUSTRIAL ENGINEER

Clinton B. Fleming has been appointed Chief Industrial Engineer at Laclede-Christy Company, Division of H. K. Porter Company, Inc., according to an announcement by R. F. Allen, Vice President of H. K. Porter Company, Inc. Mr. Fleming will be in charge of all industrial engineering at Laclede-Christy plants.

Previously, Mr. Fleming was Plant Engineer for Buffalo Steel Division of H. K. Porter Company, Inc., and Industrial Engineer for Kimberly-Clark Corporation. He is an engineering graduate of the University of Buffalo and did graduate work there.

• Frank Y. Speight has joined the staff of the American Society for Testing Materials as Assistant Technical Secretary. He has been formerly associated with the National Academy of Sciences, National Research Council, Advisory Board on Quartermaster Research and Development and the American Cyanamid Company.

• Construction has started on a $150,000 warehouse addition to a new plant nearing completion in Sarnia, Ontario, for Fiberglas of Canada Limited, with the new plant costing over $200,000 and housing part of the manufacturing operations of the company at Oshawa, Ontario. The warehouse will cover 70,000 feet of floor space.

• The American Society for Testing Materials will hold its annual Committee Week January 31 to February 4 at Cincinnati, Ohio.

• William G. McDaniel, formerly a sales engineer with The Foxboro Company branch office in Houston, Texas, has been appointed Manager of the company's branch in Corpus Christi, Texas.

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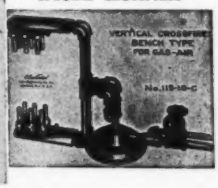

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Milestones in Glass Progress

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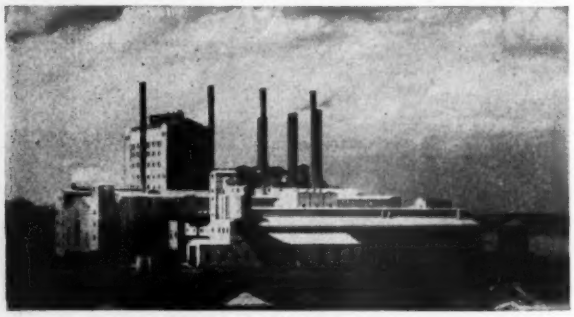
1770 This rare "Valentine" or "Betrothal" goblet is one of three recorded Early American enameled pieces bearing an English inscription, and represents the continental-peasant type of glassware. Made by Henry William Steigel, pioneer in American glassmaking, it is decorated with lovebirds, and inscribed: "My love you like me do."



1890 Michigan Alkali Company, now a division of Wyandotte Chemicals Corporation, was founded by Captain J. B. Ford to supply Soda Ash to the glass industry; part of Wyandotte's modern Soda Ash facilities is shown above. Wyandotte has literally grown up with glass. Today, as in the past, it is a working partner, supplying technical assistance and raw-material chemicals to those great companies marking milestones in glass progress.

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